

CLIMATE CHANGE

12/2011

Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2011

National Inventory Report for the German Greenhouse
Gas Inventory 1990 - 2009

**Submission under the United Nations
Framework Convention on Climate
Change and the Kyoto Protocol 2011**

**National Inventory Report for the German
Greenhouse Gas Inventory 1990 - 2009**

Federal Environment Agency, Germany

UMWELTBUNDESAMT

This publication is only available online. It can be downloaded from <http://www.uba.de/uba-info-medien-e/4127.html> along with a German-language version.

ISSN 1862-4359

Publisher: Federal Environment Agency (Umweltbundesamt)
Wörlitzer Paltz 1
06844 Dessau-Roßlau
Germany
Phone: +49-340-2103-0
Fax: +49-340-2103 2285
Email: info@umweltbundesamt.de
Internet: <http://www.umweltbundesamt.de>
<http://fuer-mensch-und-umwelt.de/>

Edited by: Section I 2.6 Emissions Situation
Michael Strogies, Patrick Gniffke

Dessau-Roßlau, June 2011

Contact

This report was produced in the framework of work of the National Co-ordination Agency (Single Entity) for the *National System of Emissions Inventories (Nationales System Emissionsinventare; NaSE)*, sited within the Federal Environment Agency (UBA). Contributions for the chapters on agriculture, and on land use, land-use changes and forestry, were prepared by the Johann Heinrich von Thünen Institute (vTI).

The electronic version of this report, along with the pertinent emissions data in the Common Reporting Format (CRF) (Version 1.60, based on the CSE database, and last revised as of 17 January 2011), is available on the Web site of the Federal Environment Agency:

<http://www.umweltbundesamt.de/emissionen/publikationen.htm>

Authors

Management of the report as a whole: Michael Strogies, Patrick Gniffke (UBA I 2.6)

For the individual chapters:

Part I: Annual deliveries for the inventories [i.p. = in part]

Chapter 1.1.1 & 1.1.2	Rosemarie Benndorf (UBA I 2.1)
Chapter 1.1.3, 1.2.1 i.p., 1.2.3, 1.3 i.p., 1.6 i.p.	Dirk Günther (UBA I 2.6)
Chapter 1.2.1.6, 1.2.2, 1.3.2, 1.3.3, 1.6 i.p.	Stephan Schiller (UBA I 2.6)
Chapter 1.3.3.1.7, 1.6.2 i.p.	Robert Kludt (UBA I 2.6)
Chapter 1.3.2.4, 1.5, 2, 3.2.1, 3.2.3-5, 3.2.13	Michael Strogies (UBA I 2.6)
Chapter 1.7., 1.8	Detlef Rimkus (UBA I 2.6)
Chapter 3.2	Petra Icha, Jens Langenfeld (UBA I 2.5), Marion Dreher (UBA I 2.5), Kristina Juhrich (UBA I 2.6)
Chapter 3.2.2.2	Sabine Gores (Öko-Institut Berlin), Michael Kotzulla (UBA I 2.6), Frank Wetzel (UBA I 3.2)
Chapter 3.2.2.3	Katharina Koppe (UBA I 3.2), Michael Kotzulla (UBA I 2.6)
Chapter 3.2.6 – 3.2.8, 3.2.9.6	Petra Icha, Jens Langenfeld (UBA I 2.5), Rolf Beckers (UBA III 2.3-K), Kristina Juhrich (UBA I 2.6)
Chapter 3.2.9.1	Petra Icha (UBA I 2.5), Sebastian Plickert (UBA III 2.2)
Chapter 3.2.9.2 - 3.2.9.3, 3.2.9.5, 3.2.9.7 - 3.2.9.11	Petra Icha (UBA I 2.5)
Chapter 3.2.9.4	Petra Icha (UBA I 2.5), Almut Reichart (UBA III 2.3-K)
Chapter 3.2.10.1	Sabine Gores (Öko-Institut Berlin), Michael Kotzulla (UBA I 2.6), Frank Wetzel (UBA I 3.2)
Chapter 3.2.10.2 - 3.2.10.5	Gunnar Gohlsch, Nadja Richter (UBA I 3.1)
Chapter 3.2.11 + 3.2.12	Anja Behnke (UBA III 2.3-K), Reinhard Böhnke (UBA I 2.5)
Chapter 3.3.1	Jürgen Ilse (Gesamtverband Steinkohle), Christian Böttcher (UBA I.2.6); Sebastian Plickert (UBA III 2.2)
Chapter 3.3.2	Edda Hoffmann (UBA III 2.3-K), Karen Pannier (UBA III 2.3-K); Christiane Lohse (UBA I 2.3) Christian Böttcher (UBA I.2.6)
Chapter 4.2.1 - 4.2.2	Maja Bernicke (UBA III 2.2)
Chapter 4.2.3	Robert Kludt (UBA I 2.6)
Chapter 4.2.4	Birgit Brahner (UBA III 2.3-K)
Chapter 4.2.5 & 4.2.6	Robert Kludt (UBA I 2.6)
Chapter 4.2.7	Sandra Leuthold (UBA III 2.2)
Chapter 4.2.8	Maja Bernicke (UBA III 2.2)
Chapter 4.3.1 & 4.3.2	Birgit Brahner (UBA III 2.3-K)
Chapter 4.3.3	Johannes Drotleff (UBA III 2.3-K)
Chapter 4.3.4	Birgit Brahner (UBA III 2.3-K)
Chapter 4.3.5	Birgit Brahner (UBA III 2.3-K), Johannes Drotleff (UBA III 2.3-K), Edda Hoffmann (UBA III 2.3-K)

Chapter 4.4.1	Sebastian Plickert (UBA III 2.2)
Chapter 4.4.2 & 4.4.3	Christian Lehmann (UBA III 2.2)
Chapter 4.4.4	Cornelia Elsner (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 4.4.5	Cornelia Elsner (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 4.5	Cornelia Elsner (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 4.5.2	Ulrich Gromke (UBA III 2.3-K)
Chapter 4.6 - 4.7	Kerstin Martens (UBA III 1.4), Cornelia Elsner (UBA III 1.4) David Kuntze (UBA I 2.6)
Chapter 5.2	Folke Dettling (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 5.3	Folke Dettling (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 6	Johann Heinrich von Thünen-Institut (vTI AK): Claus Rösemann, Hans-Dieter Haenel
Chapter 7.2	Johann Heinrich von Thünen-Institut (vTI WOI): Wolfgang Stümer, Katja Oehmichen, Thomas Riedel, Daniel Ziche, Erik Grüneberg, Nicole Wellbrock, Johanna Steuk, Karsten Dunger
Chapter 7.3 -7.8	Johann Heinrich von Thünen-Institut (vTI AK): Annette Freibauer, Andreas Gensior, Andreas Laggner
Chapter 8.2	Wolfgang Butz (UBA III 2.4)
Chapter 8.3	Dietmar Wunderlich, Christine Galander (UBA III 2.5)
Chapter 8.5	Tim Hermann, Wolfgang Butz (UBA III 2.4)
Chapter 10	Michael Kotzulla (UBA I 2.6)

Part II: Supplementary information as required under Article 7 (1) of the Kyoto Protocol:

Chapter 11	Johann Heinrich von Thünen-Institut (vTI WOI): Karsten Dunger, Katja Oehmichen, Wolfgang Stümer
Chapter 11.7,12, 14	Deutsche Emissionshandelsstelle (DEHSt):
Chapter 13	Dirk Günther (UBA I 2.6)
Chapter 15	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), Referat KI 1.1

Annexes:

Annex 1, 4	Michael Strogies (UBA I 2.6)
Annex 2	Jens Langenfeld (UBA I 2.5), Kristina Juhrich (UBA I 2.6), Marcus Machat (UBA E 1.1), Petra Icha (UBA I 2.5)
Annex 2, Chapter 18.6	Kristina Juhrich (UBA I 2.6)
Annex 2, 18.7	Michael Strogies (UBA I 2.6)
Annex 3	Authors in keeping with specialised responsibility, in Chapter 3-15
Annex 3, Chapter 19.1.1	Marcus Machat (UBA E 1.1), Frank Zander (Institut für Energetik und Umwelt: IE gGmbH), Dr. Dieter Merten (IE gGmbH)
Annex 3, Chapter 19.5.1	Johann Heinrich von Thünen-Institut (vTI WOI): Katja Oehmichen, Karsten Dunger, Johanna Steuk, Wolfgang Stümer, Thomas Riedel
Annex 5	Detlef Rimkus (UBA I 2.6)
Annex 6	Dirk Günther (UBA I 2.6), Authors in keeping with specialised responsibility
Annex 6, Chapter 22.1.3	Stephan Schiller (UBA I 2.6)
Annex 6, Chapter 22.1.3	Kevin Hausmann (UBA I 2.6)
Annex 7	Detlef Rimkus (UBA I 2.6)

Imprint

Published by: Umweltbundesamt (Federal Environment Agency), Wörlitzer Platz 1, 06844 Dessau, Deutschland

Information from this report may be reproduced, provided the source is acknowledged.

Contents

LIST OF FIGURES	29
LIST OF TABLES	32
LIST OF ABBREVIATIONS	44
UNITS AND SIZES	50
HOW TO READ THE INTRODUCTORY INFORMATION TABLES	51
0 SUMMARY (ES)	52
0.1 BACKGROUND INFORMATION ON GREENHOUSE-GAS INVENTORIES AND CLIMATE CHANGE (ES.1)	53
0.1.1 Background information about climate change (ES1.1)	53
0.1.2 Background information about greenhouse-gas inventories (ES1.2)	54
0.1.3 Background information relative to supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol (ES.1.3)	54
0.2 COMBINED GREENHOUSE-GAS EMISSIONS, THEIR STORAGE IN SINKS, AND EMISSIONS AND STORAGE FROM KP-LULUCF ACTIVITIES (ES.2)	55
0.2.1 Greenhouse-gas inventory (ES.2.1)	55
0.2.2 KP-LULUCF activities (ES.2.2)	57
0.3 COMBINED EMISSIONS ESTIMATES, AND TRENDS FOR SOURCE AND SINK GROUPS, INCLUDING KP-LULUCF ACTIVITIES (ES.3)	57
0.3.1 Greenhouse-gas inventory (ES.3.1)	57
0.3.2 KP-LULUCF activities (ES.3.2)	59
1 INTRODUCTION	60
1.1 BACKGROUND INFORMATION REGARDING GREENHOUSE-GAS INVENTORIES AND CLIMATE CHANGE, AND SUPPLEMENTARY INFORMATION AS REQUIRED PURSUANT TO ARTICLE 7 (1) OF THE KYOTO PROTOCOL	60
1.1.1 Background information about climate change	60
1.1.2 Background information about greenhouse-gas inventories	61
1.1.3 Background information relative to supplementary information, as required pursuant to Article 7 (1) of the Kyoto Protocol (KP NIR 1.1.3.)	62
1.2 DESCRIPTION OF INSTITUTIONALISATION OF INVENTORY PREPARATION, INCLUDING THE LEGAL AND PROCEDURAL DEFINITIONS RELATIVE TO THE PLANNING, PREPARATION AND MANAGEMENT OF THE INVENTORY	62
1.2.1 Overview of the institutional, legal and procedural definitions relative to preparation of greenhouse-gas inventories and of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol	63
1.2.1.1 The National Co-ordinating Committee	64
1.2.1.2 Co-ordination agency (SNE) for the National System	64
1.2.1.3 Working Group on Emissions Inventories, in the Federal Environment Agency	66
1.2.1.4 Co-operation between the Single National Entity and a) other federal institutions and b) non-governmental organisations	66
1.2.1.5 Directive 11/2005 of the Federal Environment Agency	69
1.2.1.6 Binding schedule in the framework of the National System	69
1.2.2 Overview of inventory planning	70
1.2.3 Overview of inventory preparation and management, including overview of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol	70
1.3 INVENTORY PREPARATION	72
1.3.1 Greenhouse-gas and KP-LULUCF inventories	72
1.3.1.1 Preliminary/upstream processes	72
1.3.1.1.1 Improvement of the National System	72
1.3.1.1.2 Implementation of improvements in inventory planning and inventory preparation	73
1.3.1.1.3 Determination of key categories (pursuant to Tier 1)	73
1.3.1.1.4 Calculation and aggregation of uncertainties relative to emissions	73
1.3.1.1.5 Expanded determination of key categories-	74
1.3.2 Data collection, processing and storage, including data for KP-LULUCF inventories	74
1.3.2.1 Definition of bases for calculation	74
1.3.2.2 Data collection	75
1.3.2.3 Data preparation and emissions calculation	76
1.3.2.4 Report preparation	77

1.3.3 Procedures for quality assurance and quality control (QA/QC), and detailed review of greenhouse-gas and KP-LULUCF inventories	79
1.3.3.1 The Quality System for Emissions Inventories	79
1.3.3.1.1 <i>Minimum requirements pertaining to a system for quality control and assurance</i>	79
1.3.3.1.2 <i>Start-up organisation for establishing the Quality System for Emissions Inventories</i>	79
1.3.3.1.3 <i>Organisation for establishing the Quality System for Emissions Inventories</i>	81
1.3.3.1.4 <i>Documentation in the Quality System for Emissions Inventories</i>	81
1.3.3.1.5 <i>The QSE handbook</i>	84
1.3.3.1.6 <i>Support provided by expert-review groups</i>	85
1.3.3.1.7 <i>Use of EU ETS monitoring data for improvement of GG-emissions inventories</i>	85
1.4 SHORT, GENERAL DESCRIPTION OF THE METHODS AND DATA SOURCES USED	86
1.4.1 Greenhouse-gas inventory	86
1.4.1.1 Data sources	86
1.4.1.1.1 <i>Energy</i>	86
1.4.1.1.2 <i>Industrial processes</i>	89
1.4.1.1.3 <i>Solvent and other product use</i>	92
1.4.1.1.4 <i>Agriculture</i>	93
1.4.1.1.5 <i>Land-use changes and forestry</i>	94
1.4.1.1.6 <i>Waste and wastewater</i>	96
1.4.1.2 Methods	97
1.4.2 KP LULUCF activities	98
1.5 BRIEF DESCRIPTION OF KEY CATEGORIES	98
1.5.1 Greenhouse-gas inventory (with and without LULUCF)	98
1.5.2 Inventory with KP-LULUCF reporting	99
1.6 INFORMATION REGARDING THE QUALITY ASSURANCE AND QUALITY CONTROL PLAN, THE INVENTORY PLAN (INCLUDING VERIFICATION) AND MANAGEMENT OF CONFIDENTIAL INFORMATION	103
1.6.1 Quality assurance and quality control procedures	103
1.6.1.1 QC/QA plan	103
1.6.1.2 Inventory plan	104
1.6.2 Activities for verification	105
1.6.2.1 Procedure for using monitoring data from European emissions trading	105
1.6.2.2 Workshop on the National System (Peer Review)	106
1.6.3 Handling of confidential information	106
1.7 GENERAL ESTIMATION OF UNCERTAINTIES	107
1.7.1 Greenhouse-gas inventory	107
1.7.1.1 Procedure for determining uncertainties pursuant to Tier 1	108
1.7.1.2 Results of uncertainties assessment	108
1.7.2 KP LULUCF inventory	110
1.8 GENERAL REVIEW OF COMPLETENESS	110
1.8.1 Greenhouse-gas inventory	110
1.8.2 KP LULUCF inventory	111
2 TRENDS IN GREENHOUSE GAS EMISSIONS	111
2.1 DESCRIPTION AND INTERPRETATION OF TRENDS IN AGGREGATED GREENHOUSE-GAS EMISSIONS	112
2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS, BY GREENHOUSE GASES	113
2.2.1 Carbon dioxide (CO ₂)	114
2.2.2 Nitrous oxide (N ₂ O)	114
2.2.3 Methane (CH ₄)	115
2.2.4 F gases	115
2.3 DESCRIPTION AND INTERPRETATION OF EMISSIONS TRENDS, BY SOURCE CATEGORIES	116
2.4 DESCRIPTION AND INTERPRETATION OF TRENDS IN EMISSIONS OF INDIRECT GREENHOUSE GASES AND OF SO₂	118
2.5 DESCRIPTION AND INTERPRETATION OF EMISSIONS TRENDS WITH REGARD TO THE KP-LULUCF INVENTORY, FOR AGGREGATED EMISSIONS AND BY ACTIVITY AND GREENHOUSE GAS	120
3 ENERGY (CRF SECTOR 1)	121
3.1 OVERVIEW (CRF SECTOR 1)	121
3.2 COMBUSTION OF FUELS (1.A)	121
3.2.1 Comparison of the sectoral approach and the Reference Approach	132

3.2.1.1	Comparison with the CO ₂ Reference Approach	132
3.2.1.2	Quality assurance / control and verification (1.A)	132
3.2.1.2.1	<i>Comparison with the IEA results</i>	134
3.2.1.2.2	<i>Comparison with the data obtained for the individual Länder</i>	135
3.2.1.2.3	<i>Planned improvements</i>	137
3.2.2	International bunker fuels	137
3.2.2.1	Emissions from international transports (1.C.1.a/1.C.1.b)	137
3.2.2.2	Emissions from international air transports (1.C.1.a)	137
3.2.2.2.1	<i>Source category description (1.C.1.a)</i>	137
3.2.2.2.2	<i>Methodological issues (1.C.1.a)</i>	138
3.2.2.2.3	<i>Uncertainties and time-series consistency (1.C.1.a)</i>	139
3.2.2.2.4	<i>Source-specific quality assurance / control (1.C.1.a)</i>	139
3.2.2.2.5	<i>Source-specific recalculations (1.C.1.a)</i>	139
3.2.2.2.6	<i>Planned improvements (1.C.1.a)</i>	140
3.2.2.3	Emissions from international maritime transport / maritime navigation (1.C.1.b)	140
3.2.2.3.1	<i>Source category description (1.C.1.b)</i>	140
3.2.2.3.2	<i>Methodological issues (1.C.1.b)</i>	141
3.2.2.3.3	<i>Uncertainties and time-series consistency (1.C.1.b)</i>	142
3.2.2.3.4	<i>Source-specific quality assurance / control and verification (1.C.1.b)</i>	142
3.2.2.3.5	<i>Source-specific recalculation (1.C.1.b)</i>	142
3.2.2.3.6	<i>Planned improvements (1.C.1.b)</i>	142
3.2.3	Storage	142
3.2.4	CO₂ capture and storage (CCS)	143
3.2.5	Special country-specific aspects	143
3.2.6	Public electricity and heat production (1.A.1.a)	143
3.2.6.1	Source category description (1.A.1.a)	143
3.2.6.2	Methodological issues (1.A.1.a)	145
3.2.6.3	Uncertainties and time-series consistency (1.A.1.a)	148
3.2.6.3.1	<i>Methods for determining uncertainties of emission factors</i>	149
3.2.6.3.2	<i>Result for N₂O</i>	149
3.2.6.3.3	<i>Result for CH₄</i>	150
3.2.6.3.4	<i>Time-series consistency of emission factors</i>	150
3.2.6.4	Source-specific quality assurance / control and verification (1.A.1.a)	151
3.2.6.5	Source-specific recalculations (1.A.1.a)	151
3.2.6.6	Source-specific planned improvements (1.A.1.a)	151
3.2.7	Petroleum refining (1.A.1.b)	152
3.2.7.1	Source category description (1.A.1.b)	152
3.2.7.2	Methodological issues (1.A.1.b)	153
3.2.7.3	Uncertainties and time-series consistency (1.A.1.b)	154
3.2.7.3.1	<i>Result for N₂O</i>	154
3.2.7.3.2	<i>Result for CH₄</i>	155
3.2.7.3.3	<i>Time-series consistency of emission factors</i>	155
3.2.7.4	Source-specific quality assurance / control and verification (1.A.1.b)	155
3.2.7.5	Source-specific recalculations (1.A.1.b)	155
3.2.7.6	Source-specific planned improvements (1.A.1.b)	155
3.2.8	Manufacture of solid fuels and other energy industries (1.A.1.c)	155
3.2.8.1	Source category description (1.A.1.c)	155
3.2.8.2	Methodological issues (1.A.1.c)	158
3.2.8.3	Uncertainties and time-series consistency (1.A.1.c)	159
3.2.8.3.1	<i>Result for N₂O</i>	159
3.2.8.3.2	<i>Result for CH₄</i>	159
3.2.8.3.3	<i>Time-series consistency of emission factors</i>	159
3.2.8.4	Source-specific quality assurance / control and verification (1.A.1.c)	159
3.2.8.5	Source-specific recalculations (1.A.1.c)	159
3.2.8.6	Source-specific planned improvements (1.A.1.c)	160
3.2.9	Manufacturing industries and construction (1.A.2)	160
3.2.9.1	Manufacturing industries and construction – iron and steel (1.A.2.a)	162
3.2.9.1.1	<i>Source category description (1.A.2.a)</i>	162
3.2.9.1.2	<i>Methodological issues (1.A.2.a)</i>	163
3.2.9.1.3	<i>Uncertainties and time-series consistency (1.A.2.a)</i>	164
3.2.9.1.4	<i>Source-specific quality assurance / control and verification (1.A.2.a)</i>	164
3.2.9.1.5	<i>Source-specific recalculations (1.A.2.a)</i>	165
3.2.9.1.6	<i>Source-specific planned improvements (1.A.2.a)</i>	165
3.2.9.2	Manufacturing industries and construction – non-ferrous metals (1.A.2.b)	166
3.2.9.2.1	<i>Source category description (1.A.2.b)</i>	166

3.2.9.2.2	Methodological issues (1.A.2.b)	166
3.2.9.2.3	Uncertainties and time-series consistency (1.A.2.b)	166
3.2.9.2.4	Source-specific quality assurance / control and verification (1.A.2.b)	166
3.2.9.2.5	Source-specific recalculations (1.A.2.b)	167
3.2.9.2.6	Source-specific planned improvements (1.A.2.b)	167
3.2.9.3	Manufacturing industries and construction – Chemicals (1.A.2.c)	167
3.2.9.4	Manufacturing industries and construction – Pulp, paper and print (1.A.2.d)	168
3.2.9.4.1	Source category description (1.A.2.d)	168
3.2.9.4.2	Methodological issues (1.A.2.d)	168
3.2.9.4.3	Uncertainties and time-series consistency (1.A.2.d)	168
3.2.9.4.4	Source-specific quality assurance / control and verification (1.A.2.d)	169
3.2.9.4.5	Source-specific recalculations (1.A.2.d)	169
3.2.9.4.6	Source-specific planned improvements (1.A.2.d)	169
3.2.9.5	Manufacturing industries and construction – Sugar production (1.A.2.e)	169
3.2.9.5.1	Source category description (1.A.2.e)	169
3.2.9.5.2	Methodological issues (1.A.2.e)	170
3.2.9.5.3	Uncertainties and time-series consistency (1.A.2.e)	170
3.2.9.5.4	Source-specific quality assurance / control and verification (1.A.2.e)	170
3.2.9.5.5	Source-specific recalculations (1.A.2.e)	170
3.2.9.5.6	Source-specific planned improvements (1.A.2.e)	170
3.2.9.6	Manufacturing industries and construction – Other (1.A.2.f, Sum)	170
3.2.9.7	Manufacturing industries and construction - Cement production (1.A.2.f, Cement)	172
3.2.9.7.1	Source category description (1.A.2.f, Cement)	172
3.2.9.7.2	Methodological issues (1.A.2.f, Cement)	172
3.2.9.7.3	Uncertainties and time-series consistency (1.A.2.f, Cement)	174
3.2.9.7.4	Source-specific quality assurance / control and verification (1.A.2.f, Cement)	174
3.2.9.7.5	Source-specific recalculations (1.A.2.f Cement)	174
3.2.9.7.6	Source-specific planned improvements (1.A.2.f, Cement)	175
3.2.9.8	Manufacturing industries and construction - Ceramics (1.A.2.f, Ceramics)	175
3.2.9.8.1	Source category description (1.A.2.f, Ceramics)	175
3.2.9.8.2	Methodological issues (1.A.2.f, Ceramics)	175
3.2.9.8.3	Uncertainties and time-series consistency (1.A.2.f, Ceramics)	175
3.2.9.8.4	Source-specific quality assurance / control and verification (1.A.2.f, Ceramics)	175
3.2.9.8.5	Source-specific recalculations (1.A.2.f, Ceramics)	175
3.2.9.8.6	Source-specific planned improvements (1.A.2.f, Ceramics)	176
3.2.9.9	Manufacturing industries and construction - Glass (1.A.2.f, Glass production)	176
3.2.9.9.1	Source category description (1.A.2.f, Glass production)	176
3.2.9.9.2	Methodological issues (1.A.2.f, Glass production)	176
3.2.9.9.3	Uncertainties and time-series consistency (1.A.2.f, Glass production)	176
3.2.9.9.4	Source-specific quality assurance / control and verification (1.A.2.f, Glass production)	177
3.2.9.9.5	Source-specific recalculations (1.A.2.f, Glass production)	177
3.2.9.9.6	Source-specific planned improvements (1.A.2.f, Glass production)	177
3.2.9.10	Manufacturing industries and construction - Lime (1.A.2.f, Lime production)	177
3.2.9.10.1	Source category description (1.A.2.f, Lime production)	177
3.2.9.10.2	Methodological issues (1.A.2.f, Lime production)	177
3.2.9.10.3	Uncertainties and time-series consistency (1.A.2.f, Lime production)	178
3.2.9.10.4	Source-specific quality assurance / control and verification (1.A.2.f, Lime production)	179
3.2.9.10.5	Source-specific recalculations (1.A.2.f, Lime production)	179
3.2.9.10.6	Source-specific planned improvements (1.A.2.f, Lime production)	179
3.2.9.11	Manufacturing industries and construction - Other energy production (1.A.2.f, Other)	179
3.2.9.11.1	Source category description (1.A.2.f Other)	180
3.2.9.11.2	Methodological issues (1.A.2.f Other)	180
3.2.9.11.3	Uncertainties and time-series consistency (1.A.2.f Other)	181
3.2.9.11.4	Source-specific quality assurance / control and verification (1.A.2.f Other)	181
3.2.9.11.5	Source-specific recalculations (1.A.2.f Other)	182
3.2.9.11.6	Source-specific planned improvements (1.A.2.f Other)	182
3.2.10	Transport (1.A.3)	183
3.2.10.1	Transport - Civil aviation (1.A.3.a)	183
3.2.10.1.1	Source category description (1.A.3.a)	183
3.2.10.1.2	Methodological issues (1.A.3.a)	184
3.2.10.1.3	Uncertainties and time-series consistency (1.A.3.a)	188
3.2.10.1.4	Source-specific quality assurance / control and verification (1.A.3.a)	189
3.2.10.1.5	Source-specific recalculations (1.A.3.a)	190
3.2.10.1.6	Source-specific planned improvements (1.A.3.a)	191
3.2.10.2	Transport – Road transport (1.A.3.b)	192

3.2.10.2.1	Source category description (1.A.3.b)	192
3.2.10.2.2	Methodological issues (1.A.3.b)	192
3.2.10.2.3	Uncertainties and time-series consistency (1.A.3.b)	195
3.2.10.2.4	Source-specific quality assurance / control and verification (1.A.3.b)	195
3.2.10.2.5	Source-specific recalculations (1.A.3.b)	196
3.2.10.2.6	Source-specific planned improvements (1.A.3.b)	196
3.2.10.3	Transport – Railways (1.A.3.c)	197
3.2.10.3.1	Source category description (1.A.3.c)	197
3.2.10.3.2	Methodological issues (1.A.3.c)	198
3.2.10.3.3	Uncertainties and time-series consistency (1.A.3.c)	200
3.2.10.3.4	Source-specific quality assurance / control and verification (1.A.3.c)	200
3.2.10.3.5	Source-specific recalculations (1.A.3.c)	200
3.2.10.3.6	Source-specific planned improvements (1.A.3.c)	201
3.2.10.4	Transport – Navigation (1.A.3.d)	202
3.2.10.4.1	Source category description (1.A.3.d)	202
3.2.10.4.2	Methodological issues (1.A.3.d)	203
3.2.10.4.3	Uncertainties and time-series consistency (1.A.3.d)	204
3.2.10.4.4	Source-specific quality assurance / control and verification (1.A.3.d)	205
3.2.10.4.5	Source-specific recalculations (1.A.3.d)	205
3.2.10.4.6	Source-specific planned improvements (1.A.3.d)	206
3.2.10.5	Transport – Other transport (1.A.3.e)	207
3.2.10.5.1	Source category description (1.A.3.e)	207
3.2.10.5.2	Methodological issues (1.A.3.e)	207
3.2.10.5.3	Uncertainties and time-series consistency (1.A.3.e)	208
3.2.10.5.4	Source-specific quality assurance / control and verification (1.A.3.e)	209
3.2.10.5.5	Source-specific recalculations (1.A.3.e)	209
3.2.10.5.6	Source-specific planned improvements (1.A.3.e)	210
3.2.11	Other: Residential, commercial/institutional, agriculture, forestry and fisheries (1.A.4)	211
3.2.11.1	Source category description (1.A.4)	211
3.2.11.2	Methodological issues (1.A.4)	214
3.2.11.3	Uncertainties and time-series consistency (1.A.4)	216
3.2.11.4	Source-specific quality assurance / control and verification (1.A.4)	217
3.2.11.5	Source-specific recalculations (1.A.4)	218
3.2.11.6	Source-specific planned improvements (1.A.4)	219
3.2.12	Other (1.A.5)	219
3.2.12.1	Source category description (1.A.5)	219
3.2.12.2	Methodological issues (1.A.5)	220
3.2.12.3	Uncertainties and time-series consistency (1.A.5)	222
3.2.12.4	Source-specific quality assurance / control and verification (1.A.5)	222
3.2.12.5	Source-specific recalculations (1.A.5)	222
3.2.13	Military	223
3.3	FUGITIVE EMISSIONS FROM FUELS (1.B)	223
3.3.1	Solid fuels (1.B.1)	224
3.3.1.1	Coal mining and handling (1.B.1.a)	226
3.3.1.1.1	General description of the source category Coal mining and handling (1.B.1.a)	226
3.3.1.1.2	Methodological issues (1.B.1.a)	227
3.3.1.1.3	Uncertainties and time-series consistency (1.B.1.a)	228
3.3.1.1.4	Source-specific quality assurance / control and verification (1.B.1.a)	229
3.3.1.1.5	Source-specific recalculations (1.B.1.a)	229
3.3.1.1.6	Source-specific planned improvements (1.B.1.a)	229
3.3.1.2	Solid fuel transformation (1.B.1.b)	230
3.3.1.2.1	Source category description (1.B.1.b)	230
3.3.1.2.2	Methodological issues (1.B.1.b)	230
3.3.1.2.3	Uncertainties and time-series consistency (1.B.1.b)	230
3.3.1.2.4	Source-specific quality assurance / control and verification (1.B.1.b)	231
3.3.1.2.5	Source-specific recalculations (1.B.1.b)	231
3.3.1.2.6	Source-specific planned improvements (1.B.1.b)	231
3.3.1.3	Other (1.B.1.c)	231
3.3.1.3.1	Source category description (1.B.1.c)	231
3.3.1.3.2	Methodological issues (1.B.1.c)	233
3.3.1.3.3	Uncertainties and time-series consistency (1.B.1.c)	233
3.3.1.3.4	Source-specific quality assurance / control and verification (1.B.1.c)	233
3.3.1.3.5	Source-specific recalculations (1.B.1.c)	233
3.3.1.3.6	Source-specific planned improvements (1.B.1.c)	234

3.3.2 Oil and natural gas (1.B.2)	234
3.3.2.1 Recalculations and time-series consistency (1.B.2 all)	234
3.3.2.2 Planned improvements (1.B.2, all)	235
3.3.2.3 Oil (1.B.2.a)	235
3.3.2.3.1 <i>Oil, Exploration (1.B.2.a.i)</i>	235
3.3.2.3.1.1 Source category description (1.B.2.a.i)	235
3.3.2.3.1.2 Methodological issues (1.B.2.a.i)	235
3.3.2.3.1.3 Uncertainties and time-series consistency (1.B.2.a.i)	235
3.3.2.3.1.4 Source-specific quality assurance / control and verification (1.B.2.a.i)	236
3.3.2.3.1.5 Source-specific recalculations (1.B.2.a.i)	236
3.3.2.3.1.6 Source-specific planned improvements (1.B.2.a.i)	236
3.3.2.3.2 <i>Oil, Production (1.B.2.a.ii)</i>	236
3.3.2.3.2.1 Source category description (1.B.2.a.ii)	236
3.3.2.3.2.2 Methodological issues (1.B.2.a.ii)	237
3.3.2.3.2.3 Uncertainties and time-series consistency (1.B.2.a.ii)	237
3.3.2.3.2.4 Source-specific quality assurance / control and verification (1.B.2.a.ii)	237
3.3.2.3.2.5 Source-specific recalculations (1.B.2.a.ii)	237
3.3.2.3.2.6 Source-specific planned improvements (1.B.2.a.ii)	237
3.3.2.3.3 <i>Oil, Transport (1.B.2.a.iii)</i>	237
3.3.2.3.3.1 Source category description (1.B.2.a.iii)	237
3.3.2.3.3.2 Methodological issues (1.B.2.a.iii)	238
3.3.2.3.3.3 Uncertainties and time-series consistency (1.B.2.a.iii)	238
3.3.2.3.3.4 Source-specific quality assurance / control and verification (1.B.2.a.iii)	238
3.3.2.3.3.5 Source-specific recalculations (1.B.2.a.iii)	238
3.3.2.3.3.6 Source-specific planned improvements (1.B.2.a.iii)	238
3.3.2.3.4 <i>Oil, refining and storage (1.B.2.a.iv)</i>	238
3.3.2.3.4.1 Source category description (1.B.2.a.iv)	239
3.3.2.3.4.2 Methodological issues (1.B.2.a.iv)	240
3.3.2.3.4.3 Uncertainties and time-series consistency (1.B.2.a.iv)	240
3.3.2.3.4.4 Source-specific quality assurance / control and verification (1.B.2.a.iv)	240
3.3.2.3.4.5 Source-specific recalculations (1.B.2.a.iv)	241
3.3.2.3.4.6 Source-specific planned improvements (1.B.2.a.iv)	241
3.3.2.3.5 <i>Oil, distribution of oil products (1.B.2.a.v)</i>	241
3.3.2.3.5.1 Source category description (1.B.2.a.v)	241
3.3.2.3.5.2 Methodological issues (1.B.2.a.v)	243
3.3.2.3.5.3 Uncertainties and time-series consistency (1.B.2.a.v)	244
3.3.2.3.5.4 Source-specific quality assurance / control and verification (1.B.2.a.v)	244
3.3.2.3.5.5 Source-specific recalculations (1.B.2.a.v)	244
3.3.2.3.5.6 Source-specific planned improvements (1.B.2.a.v)	244
3.3.2.3.6 <i>Oil, other (1.B.2.a.vi)</i>	244
3.3.2.3.6.1 Source category description (1.B.2.a.vi)	245
3.3.2.3.6.2 Methodological issues (1.B.2.a.vi)	245
3.3.2.3.6.3 Uncertainties and time-series consistency (1.B.2.a.vi)	245
3.3.2.3.6.4 Source-specific quality assurance / control and verification (1.B.2.a.vi)	245
3.3.2.3.6.5 Source-specific recalculations (1.B.2.a.vi)	245
3.3.2.3.6.6 Source-specific planned improvements (1.B.2.a.vi)	245
3.3.2.4 Natural gas (1.B.2.b)	245
3.3.2.4.1 <i>Natural gas, exploration (1.B.2.b.i.)</i>	245
3.3.2.4.1.1 Source category description (1.B.2.b.i)	245
3.3.2.4.1.2 Methodological issues (1.B.2.b.i)	246
3.3.2.4.1.3 Uncertainties and time-series consistency (1.B.2.b.i)	246
3.3.2.4.1.4 Source-specific quality assurance / control and verification (1.B.2.b.i)	246
3.3.2.4.1.5 Source-specific recalculations (1.B.2.b.i)	246
3.3.2.4.1.6 Source-specific planned improvements (1.B.2.b.i)	246
3.3.2.4.2 <i>Natural gas, production and processing (1.B.2.b.ii)</i>	246
3.3.2.4.2.1 Source category description (1.B.2.b.ii)	246
3.3.2.4.2.2 Methodological issues (1.B.2.b.ii)	247
3.3.2.4.2.3 Uncertainties and time-series consistency (1.B.2.b.ii)	248
3.3.2.4.2.4 Source-specific quality assurance / control and verification (1.B.2.b.ii)	248
3.3.2.4.2.5 Source-specific recalculations (1.B.2.b.ii)	248
3.3.2.4.2.6 Source-specific planned improvements (1.B.2.b.ii)	248
3.3.2.4.3 <i>Gas, transmission (1.B.2.b.iii)</i>	248
3.3.2.4.3.1 Source category description (1.B.2.b.iii)	248
3.3.2.4.3.2 Methodological issues (1.B.2.b.iii)	249
3.3.2.4.3.3 Uncertainties and time-series consistency (1.B.2.b.iii)	249

3.3.2.4.3.4	Source-specific quality assurance / control and verification (1.B.2.b.iii)	249
3.3.2.4.3.5	Source-specific recalculations (1.B.2.b.iii)	249
3.3.2.4.3.6	Source-specific planned improvements (1.B.2.b.iii)	250
3.3.2.4.4	<i>Gas, distribution (1.B.2.b.iv)</i>	250
3.3.2.4.4.1	Source category description (1.B.2.b.iv)	250
3.3.2.4.4.2	Methodological issues (1.B.2.b.iv)	251
3.3.2.4.4.3	Uncertainties and time-series consistency (1.B.2.b.iv)	251
3.3.2.4.4.4	Source-specific quality assurance / control and verification (1.B.2.b.iv)	251
3.3.2.4.4.5	Source-specific recalculations (1.B.2.b.iv)	252
3.3.2.4.4.6	Source-specific planned improvements (1.B.2.b.iv)	252
3.3.2.4.5	<i>Gas, other leaks (1.B.2.b.v)</i>	252
3.3.2.4.5.1	Source category description (1.B.2.b.v)	252
3.3.2.4.5.2	Methodological issues (1.B.2.b.v)	252
3.3.2.4.5.3	Uncertainties and time-series consistency (1.B.2.b.v)	252
3.3.2.4.5.4	Source-specific quality assurance / control and verification (1.B.2.b.v)	252
3.3.2.4.5.5	Source-specific recalculations (1.B.2.b.v)	253
3.3.2.4.5.6	Source-specific planned improvements (1.B.2.b.v)	253
3.3.2.4.6	<i>Venting and flaring (1.B.2.c)</i>	253
3.3.2.4.7	<i>Venting and flaring, oil (1.B.2.c.i)</i>	253
3.3.2.4.7.1	Source category description (1.B.2.c.i)	253
3.3.2.4.7.2	Methodological issues (1.B.2.c.i)	254
3.3.2.4.7.3	Uncertainties and time-series consistency (1.B.2.c.i)	254
3.3.2.4.7.4	Source-specific quality assurance / control and verification (1.B.2.c.i)	254
3.3.2.4.7.5	Source-specific recalculations (1.B.2.c.i)	254
3.3.2.4.7.6	Source-specific planned improvements (1.B.2.c.i)	254
3.3.2.4.8	<i>Venting and flaring, gas (1.B.2.c.ii)</i>	254
3.3.2.4.8.1	Source category description (1.B.2.c.ii)	255
3.3.2.4.8.2	Methodological issues (1.B.2.c.ii)	255
3.3.2.4.8.3	Uncertainties and time-series consistency (1.B.2.c.ii)	255
3.3.2.4.8.4	Source-specific quality assurance / control and verification (1.B.2.c.ii)	255
3.3.2.4.8.5	Source-specific recalculations (1.B.2.c.ii)	255
3.3.2.4.8.6	Source-specific planned improvements (1.B.2.c.ii)	255
3.3.2.5	<i>Geothermal energy (1.B.2.d)</i>	255
3.3.2.5.1	<i>Source category description (1.B.2.d)</i>	255
3.3.2.5.2	<i>Methodological issues (1.B.2.d)</i>	256
3.3.2.5.3	<i>Uncertainties and time-series consistency (1.B.2.d)</i>	256
3.3.2.5.4	<i>Source-specific quality assurance / control und –Verifizierung (1.B.2.d)</i>	257
3.3.2.5.5	<i>Source-specific recalculations (1.B.2.d)</i>	257
3.3.2.5.6	<i>Planned improvements (1.B.2.d)</i>	257
4	INDUSTRIAL PROCESSES (CRF SECTOR 2)	258
4.1	OVERVIEW (CRF SECTOR 2)	258
4.2	MINERAL PRODUCTS (2.A)	258
4.2.1	Mineral products: cement (2.A.1)	259
4.2.1.1	Source category description (2.A.1)	259
4.2.1.2	Methodological issues (2.A.1)	260
4.2.1.3	Uncertainties and time-series consistency (2.A.1)	261
4.2.1.4	Source-specific quality assurance / control and verification (2.A.1)	261
4.2.1.5	Source-specific recalculations (2.A.1)	261
4.2.1.6	Source-specific planned improvements (2.A.1)	262
4.2.2	Mineral products: lime production (2.A.2)	262
4.2.2.1	Source category description (2.A.2)	262
4.2.2.2	Methodological issues (2.A.2)	263
4.2.2.3	Uncertainties and time-series consistency (2.A.2)	264
4.2.2.4	Source-specific quality assurance / control and verification (2.A.2)	264
4.2.2.5	Source-specific recalculations (2.A.2)	264
4.2.2.6	Source-specific planned improvements (2.A.2)	264
4.2.3	Mineral products: Limestone and dolomite use (2.A.3)	265
4.2.3.1	Source category description (2.A.3)	265
4.2.3.2	Methodological issues (2.A.3)	266
4.2.3.3	Uncertainties and time-series consistency (2.A.3)	268
4.2.3.4	Source-specific quality assurance / control and verification (2.A.3)	268
4.2.3.5	Source-specific recalculations (2.A.3)	268
4.2.3.6	Source-specific planned improvements (2.A.3)	269
4.2.4	Mineral products: Soda ash production and use (2.A.4)	269

4.2.4.1	Source category description (2.A.4)	269
4.2.4.2	Methodological issues (2.A.4)	270
4.2.4.3	Uncertainties and time-series consistency (2.A.4)	271
4.2.4.4	Source-specific quality assurance / control and verification (2.A.4)	271
4.2.4.5	Source-specific recalculations (2.A.4)	271
4.2.4.6	Source-specific planned improvements (2.A.4)	271
4.2.5	Mineral Products: Bitumen for roofing (2.A.5)	272
4.2.5.1	Source category description (2.A.5)	272
4.2.5.2	Methodological issues (2.A.5)	272
4.2.5.3	Uncertainties and time-series consistency (2.A.5)	273
4.2.5.4	Source-specific quality assurance / control and verification (2.A.5)	273
4.2.5.5	Source-specific recalculations (2.A.5)	273
4.2.5.6	Source-specific planned improvements (2.A.5)	273
4.2.6	Mineral Products: Road paving with asphalt (2.A.6)	274
4.2.6.1	Source category description (2.A.6)	274
4.2.6.2	Methodological issues (2.A.6)	274
4.2.6.3	Uncertainties and time-series consistency (2.A.6)	275
4.2.6.4	Source-specific quality assurance / control and verification (2.A.6)	275
4.2.6.5	Source-specific recalculations (2.A.6)	275
4.2.6.6	Source-specific planned improvements (2.A.6)	275
4.2.7	Mineral products: Glass production (2.A.7 Glass)	275
4.2.7.1	Source category description (2.A.7 Glass)	275
4.2.7.2	Methodological issues (2.A.7 Glass)	277
4.2.7.3	Uncertainties and time-series consistency (2.A.7 Glass)	278
4.2.7.4	Source-specific quality assurance / control and verification (2.A.7 Glass)	279
4.2.7.5	Source-specific recalculations (2.A.7 Glass)	279
4.2.7.6	Source-specific planned improvements (2.A.7 Glass)	279
4.2.8	Mineral Products: Ceramics production (2.A.7 Ceramics)	280
4.2.8.1	Source category description (2.A.7 Ceramics)	280
4.2.8.2	Methodological issues (2.A.7 Ceramics)	281
4.2.8.3	Uncertainties and time-series consistency (2.A.7 Ceramics)	281
4.2.8.4	Source-specific quality assurance / control and verification (2.A.7 Ceramics)	282
4.2.8.5	Source-specific recalculations (2.A.7 Ceramics)	282
4.2.8.6	Source-specific planned improvements (2.A.7 Ceramics)	282
4.3	CHEMICAL INDUSTRY (2.B)	282
4.3.1	Chemical industry: Ammonia production (2.B.1)	283
4.3.1.1	Source category description (2.B.1)	283
4.3.1.2	Methodological issues (2.B.1)	284
4.3.1.3	Uncertainties and time-series consistency (2.B.1)	284
4.3.1.4	Source-specific quality assurance / control and verification (2.B.1)	284
4.3.1.5	Source-specific recalculations (2.B.1)	285
4.3.1.6	Source-specific planned improvements (2.B.1)	285
4.3.2	Chemical industry: Nitric acid production (2.B.2)	285
4.3.2.1	Source category description (2.B.2)	285
4.3.2.2	Methodological issues (2.B.2)	286
4.3.2.3	Uncertainties and time-series consistency (2.B.2)	286
4.3.2.4	Source-specific quality assurance / control and verification (2.B.2)	287
4.3.2.5	Source-specific recalculations (2.B.2)	287
4.3.2.6	Source-specific planned improvements (2.B.2)	287
4.3.3	Chemical industry: Adipic acid production (2.B.3)	287
4.3.3.1	Source category description (2.B.3)	287
4.3.3.2	Methodological issues (2.B.3)	288
4.3.3.3	Uncertainties and time-series consistency (2.B.3)	288
4.3.3.4	Source-specific quality assurance / control and verification (2.B.3)	288
4.3.3.5	Source-specific recalculations (2.B.3)	288
4.3.3.6	Source-specific planned improvements (2.B.3)	288
4.3.4	Chemical industry: Carbide production (2.B.4)	289
4.3.4.1	Source category description (2.B.4)	289
4.3.4.2	Methodological issues (2.B.4)	289
4.3.4.3	Uncertainties and time-series consistency (2.B.4)	290
4.3.4.4	Source-specific quality assurance / control and verification (2.B.4)	290
4.3.4.5	Source-specific recalculations (2.B.4)	290
4.3.4.6	Source-specific planned improvements (2.B.4)	290
4.3.5	Chemical industry – other: Emissions from other production processes (2.B.5)	290
4.3.5.1	Source category description (2.B.5)	290

4.3.5.2	Methodological issues (2.B.5)	291
4.3.5.3	Uncertainties and time-series consistency (2.B.5)	294
4.3.5.4	Source-specific quality assurance / control and verification (2.B.5)	294
4.3.5.5	Source-specific recalculations (2.B.5)	294
4.3.5.6	Source-specific planned improvements (2.B.5)	296
4.4	METAL PRODUCTION (2.C)	296
4.4.1	Metal production: Iron and steel production (2.C.1)	296
4.4.1.1	Source category description (2.C.1)	296
4.4.1.2	Methodological issues (2.C.1)	296
4.4.1.3	Uncertainties and time-series consistency (2.C.1)	300
4.4.1.4	Source-specific quality assurance / control and verification (2.C.1)	301
4.4.1.5	Source-specific recalculations (2.C.1)	301
4.4.1.6	Source-specific planned improvements (2.C.1)	302
4.4.2	Metal production: Ferroalloys production (2.C.2)	302
4.4.2.1	Source category description (2.C.2)	302
4.4.2.2	Methodological issues (2.C.2)	303
4.4.2.3	Uncertainties and time-series consistency (2.C.2)	303
4.4.2.4	Source-specific quality assurance / control and verification (2.C.2)	303
4.4.2.5	Source-specific recalculations (2.C.2)	303
4.4.2.6	Source-specific planned improvements (2.C.2)	303
4.4.3	Metal production: Primary aluminium production (2.C.3)	304
4.4.3.1	Source category description (2.C.3)	304
4.4.3.2	Methodological issues (2.C.3)	304
4.4.3.3	Uncertainties and time-series consistency (2.C.3)	305
4.4.3.4	Source-specific quality assurance / control and verification (2.C.3)	306
4.4.3.5	Source-specific recalculations (2.C.3)	306
4.4.3.6	Source-specific planned improvements (2.C.3)	306
4.4.4	Metal production: SF₆ used in aluminium and magnesium foundries (2.C.4)	307
4.4.4.1	Source category description (2.C.4)	307
4.4.4.2	Methodological issues (2.C.4)	307
4.4.4.3	Uncertainties and time-series consistency (2.C.4)	308
4.4.4.4	Source-specific quality assurance / control and verification (2.C.4)	308
4.4.4.5	Source-specific recalculations (2.C.4)	309
4.4.4.6	Source-specific planned improvements (2.C.4)	309
4.4.5	Metal production: Other (2.C.5)	309
4.4.5.1	Source category description (2.C.5)	309
4.4.5.2	Methodological issues (2.C.5)	309
4.4.5.3	Uncertainties and time-series consistency (2.C.5)	309
4.4.5.4	Source-specific recalculations (2.C.5)	309
4.4.5.5	Source-specific planned improvements (2.C.5)	310
4.4.5.6	Source-specific quality assurance / control and verification (2.C.5)	310
4.5	OTHER PRODUCTION (2.D.)	310
4.5.1	Other production: Pulp and paper (2.D.1)	310
4.5.1.1	Source category description (2.D.1)	310
4.5.1.2	Methodological issues (2.D.1)	311
4.5.1.3	Uncertainties and time-series consistency (2.D.1)	311
4.5.1.4	Source-specific quality assurance / control and verification (2.D.1)	312
4.5.1.5	Source-specific recalculations (2.D.1)	312
4.5.1.6	Source-specific planned improvements (2.D.1)	312
4.5.2	Other production: Food and drink (2.D.2)	312
4.5.2.1	Source category description (2.D.2)	312
4.5.2.2	Methodological issues (2.D.2)	313
4.5.2.3	Uncertainties and time-series consistency (2.D.2)	314
4.5.2.4	Source-specific quality assurance / control and verification (2.D.2)	314
4.5.2.5	Source-specific recalculations (2.D.2)	314
4.5.2.6	Source-specific planned improvements (2.D.2)	314
4.6	PRODUCTION OF HALOCARBONS AND SF₆ (2.E)	315
4.6.1	By-product emissions (2.E.1)	315
4.6.1.1	Source category description (2.E.1)	315
4.6.1.2	Methodological issues (2.E.1)	315
4.6.1.3	Uncertainties and time-series consistency (2.E.1)	316
4.6.1.4	Source-specific quality assurance / control and verification (2.E.1)	316
4.6.1.5	Source-specific recalculations (2.E.1)	316
4.6.1.6	Source-specific planned improvements (2.E.1)	316

4.6.2 Production-related emissions (2.E.2)	316
4.6.2.1 Source category description (2.E.2)	316
4.6.2.2 Methodological issues (2.E.2)	316
4.6.2.3 Uncertainties and time-series consistency (2.E.2)	317
4.6.2.4 Source-specific quality assurance / control and verification (2.E.2)	317
4.6.2.5 Source-specific recalculations (2.E.2)	317
4.6.2.6 Source-specific planned improvements (2.E.2)	317
4.6.3 Other (2.E.3)	317
4.7 CONSUMPTION OF HALOCARBONS AND SF₆ (2.F)	317
4.7.1 Refrigeration and air conditioning systems (2.F.1)	321
4.7.1.1 Source category description (2.F.1)	321
4.7.1.2 Methodological issues (2.F.1)	321
4.7.1.2.1 Household refrigeration (2.F.1.a)	321
4.7.1.2.2 Commercial refrigeration (2.F.1.b)	322
4.7.1.2.3 Transport refrigeration (refrigerated vehicles and containers) (2.F.1.c)	323
4.7.1.2.4 Industrial refrigeration (2.F.1.d)	325
4.7.1.2.5 Stationary air conditioning systems (2.F.1.e)	326
4.7.1.2.5.1 Room air conditioners	326
4.7.1.2.5.2 Large air conditioning systems	327
4.7.1.2.5.3 Heat pump systems	328
4.7.1.2.6 Mobile air conditioning systems (2.F.1.f)	329
4.7.1.3 Uncertainties and time-series consistency (2.F.1 all)	330
4.7.1.4 Source-specific recalculations (2.F.1 all)	331
4.7.1.5 Source-specific planned improvements (2.F.1 all)	341
4.7.2 Foam blowing (2.F.2)	341
4.7.2.1 PUR foam products (2.F.2)	341
4.7.2.1.1 Source category description (2.F.2)	341
4.7.2.1.2 Methodological issues (2.F.2)	341
4.7.2.2 PUR foam sealants (2.F.2)	342
4.7.2.2.1 Source category description (2.F.2)	342
4.7.2.2.2 Methodological issues (2.F.2)	342
4.7.2.3 XPS hard foam (2.F.2)	343
4.7.2.3.1 Source category description (2.F.2)	343
4.7.2.3.2 Methodological issues (2.F.2)	343
4.7.2.4 Uncertainties and time-series consistency (2.F.2)	344
4.7.2.5 Source-specific recalculations (2.F.2)	345
4.7.2.6 Source-specific planned improvements (2.F.2)	345
4.7.3 Fire extinguishers (2.F.3)	345
4.7.3.1 Source category description (2.F.3)	345
4.7.3.2 Methodological issues (2.F.3)	345
4.7.3.3 Uncertainties and time-series consistency (2.F.3)	346
4.7.3.4 Source-specific recalculations (2.F.3)	346
4.7.3.5 Source-specific planned improvements (2.F.3)	346
4.7.4 Aerosols (2.F.4)	346
4.7.4.1 Metered dose inhalers (2.F.4.a)	346
4.7.4.1.1 Source category description (2.F.4.a)	346
4.7.4.1.2 Methodological issues (2.F.4.a)	346
4.7.4.2 Other aerosols (2.F.4.b)	347
4.7.4.2.1 Source category description (2.F.4.b)	347
4.7.4.2.2 Methodological issues (2.F.4.b)	348
4.7.4.3 Uncertainties and time-series consistency (2.F.4 all)	348
4.7.4.3.1 Source-specific recalculations (2.F.4 all)	348
4.7.4.3.2 Source-specific planned improvements (2.F.4 all)	349
4.7.5 Solvents (2.F.5)	349
4.7.5.1 Source category description (2.F.5)	349
4.7.5.2 Methodological issues (2.F.5)	349
4.7.5.3 Uncertainties and time-series consistency (2.F.5)	349
4.7.5.4 Source-specific recalculations (2.F.5)	349
4.7.5.5 Source-specific planned improvements (2.F.5)	349
4.7.6 Semiconductor manufacturing (2.F.6)	349
4.7.6.1 Source category description (2.F.6)	349
4.7.6.2 Methodological issues (2.F.6)	350
4.7.6.3 Source-specific recalculations (2.F.6)	350
4.7.6.4 Source-specific planned improvements (2.F.6)	350
4.7.7 Electrical equipments (2.F.7)	350

4.7.7.1	Use of electrical equipments (2.F.7.a)	350
4.7.7.1.1	Source category description (2.F.7.a)	350
4.7.7.1.2	Methodological issues (2.F.7.a)	351
4.7.7.1.3	Uncertainties and time-series consistency (2.F.7.a)	353
4.7.7.1.4	Source-specific recalculations (2.F.7.a)	354
4.7.7.1.5	Source-specific planned improvements (2.F.7.a)	354
4.7.7.2	Use in particle accelerators (2.F.7.b)	354
4.7.7.2.1	Source category description (2.F.7b)	354
4.7.7.2.2	Methodological issues (2.F.7.b)	354
4.7.7.2.3	Uncertainties and time-series consistency (2.F.7.b)	355
4.7.7.2.4	Source-specific recalculations (2.F.7b)	355
4.7.7.2.5	Source-specific planned improvements (2.F.7b)	355
4.7.8	Other (2.F.8)	355
4.7.8.1	Sound-proof glazing (2.F.8.a)	355
4.7.8.1.1	Source category description (2.F.8.a)	355
4.7.8.1.2	Methodological issues (2.F.8.a)	355
4.7.8.2	Automobile tyres (2.F.8.b)	356
4.7.8.2.1	Source category description (2.F.8.b)	356
4.7.8.2.2	Methodological issues (2.F.8.b)	357
4.7.8.3	Sport shoes (2.F.8.c)	357
4.7.8.3.1	Source category description (2.F.8.c)	357
4.7.8.3.2	Methodological issues (2.F.8.c)	357
4.7.8.4	Trace gas (2.F.8.d)	358
4.7.8.4.1	Source category description (2.F.8.d)	358
4.7.8.4.2	Methodological issues (2.F.8.d)	358
4.7.8.5	AWACS (Airborne Warning and Control System) maintenance (2.F.8.e)	358
4.7.8.5.1	Source category description (2.F.8.e)	358
4.7.8.5.2	Methodological issues (2.F.8.e)	359
4.7.8.6	Welding (2.F.8.f)	359
4.7.8.6.1	Source category description (2.F.8.f)	359
4.7.8.6.2	Methodological issues (2.F.8.f)	359
4.7.8.7	Optical glass fibre (2.F.8.g)	359
4.7.8.7.1	Source category description (2.F.8.g)	359
4.7.8.7.2	Methodological issues (2.F.8.g)	359
4.7.8.8	Photovoltaics (2.F.8.h)	360
4.7.8.8.1	Source category description (2.F.8.h)	360
4.7.8.8.2	Methodological issues (2.F.8.h)	360
4.7.8.9	Uncertainties and time-series consistency (2.F.8 all)	361
4.7.8.10	Source-specific recalculations (2.F.8 all)	361
4.7.8.11	Source-specific planned improvements (2.F.8 all)	363
4.7.9	Source-specific quality assurance / control and verification (2.F all)	363
4.8	OTHER AREAS (2.G.)	364
5	SOLVENTS AND OTHER PRODUCT USE (CRF SECTOR 3)	365
5.1	OVERVIEW (CRF SECTOR 3)	365
5.2	SOLVENTS - NMVOC (3.A-3.C & 3.D)	366
5.2.1	Source category description (3.A-3.C & 3.D)	366
5.2.2	Methodological issues (3.A-3.C & 3.D)	367
5.2.3	Uncertainties and time-series consistency (3.A-3.C & 3.D)	368
5.2.4	Source-specific quality assurance / control and verification (3.A-3.C & 3.D)	368
5.2.5	Source-specific recalculations (3.A-3.C & 3.D)	369
5.2.6	Planned improvements (source-specific) (3.A-3.C & 3.D)	371
5.3	OTHER – USE OF N₂O (3.D)	371
5.3.1	Narcotic use of N ₂ O (3.D.1)	371
5.3.1.1	Source category description (3.D.1)	371
5.3.1.2	Methodological issues (3.D.1)	373
5.3.1.3	Uncertainties and time-series consistency (3.D.1)	375
5.3.1.4	Source-specific quality assurance / control and verification (3.D.1)	375
5.3.1.5	Source-specific recalculations (3.D.1)	375
5.3.1.6	Planned improvements (source-specific) (3.D.1)	377
6	AGRICULTURE (CRF SECTOR 4)	378
6.1	OVERVIEW (CRF SECTOR 4)	378
6.1.1	Source categories and total emissions, 1990 - 2009	378

6.1.2 Resubmission 2010	378
6.1.3 The GAS-EM emissions-inventory model	379
6.1.3.1 Aims	379
6.1.3.2 Guidelines applied, and detailed report	379
6.1.3.3 Basic structure of the GAS-EM emissions-inventory model	380
6.1.3.4 The N-flow concept	381
6.1.4 Characterisation of animal stocks	382
6.1.4.1 Animal categories (CRF 4.A, 4.B)	382
6.1.4.2 Activity data (CRF 4.A, 4.B)	384
6.1.4.3 Additional information (CRF 4.A, 4.B)	386
6.1.5 Characterisation of agriculturally used soils	389
6.1.6 Total uncertainty of all emissions in Sector 4	389
6.1.7 Quality assurance and control	393
6.1.7.1 Review of input data and emissions results	393
6.1.7.2 Quality System for Emissions Inventories	393
6.1.7.3 Comparisons with the previous year's results	393
6.1.7.4 Verification	393
6.1.7.5 Reviews and reports	393
6.2 ENTERIC FERMENTATION (4.A)	394
6.2.1 Source category description (4.A)	394
6.2.2 Methodological issues (4.A)	395
6.2.2.1 Methods	395
6.2.2.2 Changes in Methods	395
6.2.2.3 Activity data and additional information (4.A)	396
6.2.2.4 Calculated emissions (4.A)	397
6.2.2.5 Emission factors (4.A)	397
6.2.3 Uncertainties and time-series consistency (4.A)	398
6.2.4 Source-specific quality assurance / control and verification (4.A)	399
6.2.5 Source-specific recalculations (4.A)	399
6.2.6 Planned improvements (4.A)	400
6.3 MANURE MANAGEMENT (4.B)	401
6.3.1 Source category description (4.B)	401
6.3.2 Methane emissions from manure management (4.B, methane)	402
6.3.2.1 Source category description (4.B, methane)	402
6.3.2.2 Methodological issues (4.B, methane)	402
6.3.2.2.1 <i>Methods (4.B, methane)</i>	402
6.3.2.2.2 <i>Methodological changes (4.B, methane)</i>	403
6.3.2.2.3 <i>Activity data and additional information (4.B, methane)</i>	403
6.3.2.2.4 <i>Calculated CH₄ emissions (4.B, methane)</i>	406
6.3.2.2.5 <i>CH₄ emission factors (4.B, methane)</i>	407
6.3.2.3 Uncertainties and time-series consistency (4.B, methane)	407
6.3.2.4 Source-specific quality assurance / control and verification (4.B, methane)	407
6.3.2.5 Source-specific recalculations (4.B, methane)	410
6.3.2.6 Planned improvements (4.B, methane)	415
6.3.3 NMVOC emissions from manure management (4.B, NMVOC)	415
6.3.3.1 Source category description (4.B, NMVOC)	415
6.3.3.2 Methodological issues (4.B, NMVOC)	415
6.3.3.2.1 <i>Methods (4.B, NMVOC)</i>	415
6.3.3.2.2 <i>Methodological changes (4.B, NMVOC)</i>	416
6.3.3.2.3 <i>Calculated NMVOC emissions (4.B, NMVOC)</i>	416
6.3.3.3 Uncertainties and time-series consistency (4.B, NMVOC)	416
6.3.3.4 Source-specific quality assurance / control and verification (4.B, NMVOC)	417
6.3.3.5 Source-specific recalculations (4.B, NMVOC)	417
6.3.3.6 Planned improvements (4.B, NMVOC)	417
6.3.4 N₂O and NO emissions from manure management (4.B, N₂O & NO)	417
6.3.4.1 Source category description (4.B, N ₂ O & NO)	417
6.3.4.2 Methodological issues (4.B, N ₂ O & NO)	418
6.3.4.2.1 <i>Methods (4.B, N₂O & NO)</i>	418
6.3.4.2.2 <i>Methodological changes (4.B, N₂O & NO)</i>	419
6.3.4.2.3 <i>Activity data and additional information (4.B(b))</i>	420
6.3.4.2.4 <i>Calculated N₂O and NO emissions</i>	422
6.3.4.2.5 <i>Emission factors (4.B, N₂O & NO)</i>	423
6.3.4.3 Uncertainties and time-series consistency (4.B, N ₂ O & NO)	424
6.3.4.4 Source-specific quality assurance / control and verification (4.B, N ₂ O & NO)	424

6.3.4.5	Source-specific recalculations (4.B, N ₂ O & NO)	425
6.3.4.6	Planned improvements (4.B, N ₂ O & NO)	428
6.4	RICE CULTIVATION (4.C)	428
6.5	AGRICULTURAL SOILS (4.D)	428
6.5.1	Source category description (4.D)	428
6.5.2	Methodological issues (4.D)	428
6.5.2.1.1	<i>Basic concept</i>	428
6.5.2.1.2	<i>Direct N₂O emissions from agricultural soils (4.Ds1.2, 4.Ds1.3)</i>	429
6.5.2.1.3	<i>Indirect N₂O emissions from agricultural soils, as a result of deposition of reactive nitrogen (4.Ds1.3)</i>	430
6.5.2.1.4	<i>Indirect N₂O emissions from agricultural soils, as a result of leaching and surface runoff (4.Ds1.3)</i>	431
6.5.2.1.5	<i>NO emissions</i>	432
6.5.2.1.6	<i>NM VOC emissions from agricultural soils and crops</i>	432
6.5.2.1.7	<i>Frac_{GASF} and Frac_{GASM}</i>	432
6.5.2.1.8	<i>The other Frac figures</i>	433
6.5.2.2	Activity data and additional information (4.D)	434
6.5.2.3	Calculated emissions from the area of agricultural soils (4.D)	435
6.5.2.4	Implied emission factors (IEF) (4.D)	436
6.5.3	Source-specific quality assurance / control and verification (4.D)	436
6.5.4	Uncertainties and time-series consistency (4.D)	438
6.5.5	Source-specific recalculations (4.D)	438
6.5.6	Planned improvements (4.D)	440
6.6	PRESCRIBED BURNING OF SAVANNAS (CLEARANCE OF LAND BY PRESCRIBED BURNING) (4.E)	441
6.7	FIELD BURNING OF AGRICULTURAL RESIDUES (4.F)	441
7	LAND USE, LAND USE CHANGES AND FORESTRY (CRF SECTOR 5)	442
7.1	OVERVIEW (CRF SECTOR 5)	442
7.2	FOREST LAND (5.A)	445
7.2.1	Source category description (5.A)	445
7.2.1.1	Forest land remaining forest land (5.A.1)	445
7.2.1.2	Land converted to forest land (5.A.2)	445
7.2.2	Information about the approaches used to determine forest area and about the land-use databases used (5.A)	445
7.2.2.1	National Forest Inventory, Inventurstudie 2008 and Datenspeicher Waldfonds	446
7.2.2.2	Survey of forest soils (BZE and BioSoil)	446
7.2.2.3	GSE Forest Monitoring: Inputs for national greenhouse-gas reporting	447
7.2.2.4	Amtliches Topographisch-Kartographisches Informationssystem (ATKIS®; Official topographic-cartographic information system)	447
7.2.3	Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.A)	448
7.2.3.1	Determination of forest area, and changes in that area, for the old German Länder	448
7.2.3.2	Determination of forest area, and changes in forest area, in the new German Länder	450
7.2.4	Methodological issues (5.A)	451
7.2.4.1	Biomass	451
7.2.4.1.1	<i>Forest land remaining forest land</i>	451
7.2.4.1.2	<i>New forest land</i>	453
7.2.4.1.3	<i>Derivation of individual-tree biomass</i>	454
7.2.4.1.4	<i>Conversion into above-ground individual-tree biomass</i>	456
7.2.4.1.5	<i>Conversion into below-ground biomass</i>	458
7.2.4.1.6	<i>Conversion of individual-tree biomass into carbon</i>	459
7.2.4.1.7	<i>Algorithms for extrapolating to relevant states in 1987, 2002, 2008</i>	459
7.2.4.1.8	<i>Algorithms for extrapolating changes between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes via the "stock-change method")</i>	460
7.2.4.1.9	<i>Interpolation of time periods, to obtain annual-change estimates</i>	461
7.2.4.2	Dead wood	461
7.2.4.2.1	<i>Forest land remaining forest land</i>	461
7.2.4.2.2	<i>New forest land</i>	462
7.2.4.3	Forest-floor litter	462
7.2.4.3.1	<i>Forest land remaining forest land</i>	462
7.2.4.3.2	<i>New forest land</i>	462
7.2.4.3.3	<i>Derivation of litter carbon stocks in 1990 (BZE I) and 2006 (BZE II/BioSoil)</i>	463

7.2.4.3.4	<i>Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II/Biosoil)</i>	463
7.2.4.4	Mineral soils	463
7.2.4.4.1	<i>Forest land remaining forest land</i>	463
7.2.4.4.2	<i>New forest land</i>	464
7.2.4.4.3	<i>Derivation of carbon stocks and carbon-stock changes</i>	464
7.2.4.4.4	<i>Results of derivation of carbon stocks and carbon-stock changes</i>	466
7.2.4.5	Organic soils	467
7.2.4.5.1	<i>Forest land remaining forest land</i>	467
7.2.4.5.2	<i>New forest land</i>	468
7.2.4.6	Other greenhouse-gas emissions from forests	468
7.2.4.6.1	<i>Liming</i>	468
7.2.4.6.2	<i>Forest fires</i>	468
7.2.4.6.3	<i>Drainage</i>	470
7.2.4.6.4	<i>Land-use changes from forest land to cropland</i>	470
7.2.5	Uncertainties and time-series consistency (5.A)	471
7.2.5.1	Uncertainties in estimation of areas affected by land-use changes	471
7.2.5.2	Uncertainties in estimation of above-ground and below-ground biomass	472
7.2.5.2.1	<i>Conversion of standing-timber volume into tree-wood volume</i>	472
7.2.5.2.2	<i>Bulk densities applying to specific tree-species groups</i>	473
7.2.5.2.3	<i>Derivation of below-ground biomass</i>	475
7.2.5.2.4	<i>Sampling error</i>	476
7.2.5.2.5	<i>Error budget</i>	480
7.2.5.3	Uncertainties in estimation pertaining to forest-floor litter and mineral soils	481
7.2.5.3.1	<i>Error in taking of samples</i>	481
7.2.5.3.2	<i>Small-scale variability</i>	482
7.2.5.3.3	<i>Representativeness of points within strata</i>	482
7.2.5.3.4	<i>Database</i>	482
7.2.5.3.5	<i>Sampling error</i>	482
7.2.5.4	Time-series consistency	483
7.2.6	Source-specific quality assurance / control and verification (5.A)	483
7.2.6.1	Biomass and dead wood	484
7.2.6.2	Litter and mineral soils	484
7.2.6.3	Comparison with results of other countries	484
7.2.7	Source-specific recalculations (5.A)	486
7.2.7.1	Forest land remaining forest land	486
7.2.7.2	New forest land	487
7.2.8	Source-specific planned improvements (5.A)	489
7.2.8.1	Land-use changes	489
7.2.8.2	Litter and mineral soils	489
7.3	CROPLAND (5.B)	490
7.3.1	Source category description (5.B)	490
7.3.2	Information about the approaches used to determine areas and about the land-use databases used (5.B)	491
7.3.3	Land-use definitions and land-use classification systems, and the manner in which such definitions and systems are reflected in the LULUCF categories (5.B)	491
7.3.4	Methodological issues (5.B)	492
7.3.4.1	Mineral soils	492
7.3.4.2	Organic soils	493
7.3.4.3	Biomass	493
7.3.5	Uncertainties and time-series consistency (5.B)	494
7.3.6	Source-specific quality assurance / control and verification (5.B)	495
7.3.7	Source-specific recalculations (5.B)	495
7.3.8	Source-specific planned improvements (5.B)	495
7.4	GRASSLAND (5.C)	496
7.4.1	Source category description (5.C)	496
7.4.2	Information about the approaches used to determine areas and about the land-use databases used (5.C)	497
7.4.3	Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.C)	497
7.4.4	Methodological issues (5.C)	497
7.4.5	Uncertainties and time-series consistency (5.C)	497
7.4.6	Source-specific quality assurance / control and verification (5.C)	497
7.4.7	Source-specific recalculations (5.C)	497

7.4.8	Source-specific planned improvements (5.C)	497
7.5	WETLANDS (5.D)	497
7.5.1	Source category description (5.D)	497
7.5.2	Information about the approaches used to determine land areas and about the land-use databases used (5.D)	498
7.5.3	Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.D)	498
7.5.4	Methodological issues (5.D)	498
7.5.5	Uncertainties and time-series consistency (5.D)	499
7.5.6	Source-specific quality assurance / control and verification (5.D)	499
7.5.7	Source-specific recalculations (5.D)	499
7.5.8	Source-specific planned improvements (5.D)	499
7.6	SETTLEMENTS (5.E)	499
7.6.1	Source category description (5.E)	499
7.6.2	Information about the approaches used to determine areas and about the land-use databases used (5.E)	500
7.6.3	Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.E)	500
7.6.4	Methodological issues (5.E)	500
7.6.5	Uncertainties and time-series consistency (5.E)	500
7.6.6	Source-specific quality assurance / control and verification (5.E)	500
7.6.7	Source-specific recalculations (5.E)	500
7.6.8	Source-specific planned improvements (5.E)	500
7.7	OTHER LAND (5.F)	501
7.7.1	Source category description (5.F)	501
7.7.2	Information about the approaches used to determine areas and about the land-use databases used (5.F)	501
7.7.3	Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.F)	501
7.7.4	Methodological issues (5.F)	501
7.7.5	Uncertainties and time-series consistency (5.F)	501
7.7.6	Source-specific quality assurance / control and verification (5.F)	501
7.7.7	Source-specific recalculations (5.F)	501
7.7.8	Source-specific planned improvements (5.F)	501
7.8	OTHER AREAS (5.G)	502
8	WASTE AND WASTE WATER (CRF SECTOR 6)	503
8.1	OVERVIEW (CRF SECTOR 6)	503
8.2	SOLID WASTE DISPOSAL ON LAND (6.A)	503
8.2.1	Managed disposal in landfills – landfilling of municipal waste (6.A.1)	504
8.2.1.1	Source category description (6.A.1)	504
8.2.1.2	Methodological issues (6.A.1)	505
8.2.1.2.1	<i>Quantities of landfilled waste</i>	506
8.2.1.2.2	<i>F (Methane-correction factor)</i>	510
8.2.1.2.3	<i>DOC</i>	510
8.2.1.2.4	<i>DOC_F</i>	511
8.2.1.2.5	<i>F = proportion of CH₄ in landfill gas</i>	511
8.2.1.2.6	<i>Half-life</i>	511
8.2.1.2.7	<i>Landfill-gas use</i>	512
8.2.1.2.8	<i>Oxidation factor</i>	513
8.2.1.3	Uncertainties and time-series consistency (6.A.1)	513
8.2.1.4	Source-specific quality assurance / control and verification (6.A.1)	513
8.2.1.5	Source-specific recalculations (6.A.1)	514
8.2.1.6	Planned improvements (6.A.1)	514
8.3	WASTEWATER HANDLING (6.B)	514
8.3.1	Methane emissions from industrial wastewater and sludge treatment (6.B.1)	515
8.3.1.1	Source category description (6.B.1)	515
8.3.2	Municipal wastewater treatment (6.B.2)	516
8.3.2.1	Methane emissions from municipal wastewater treatment (6.B.2 wastewater treatment)	516
8.3.2.1.1	<i>Source category description (6.B.2 Wastewater treatment)</i>	516
8.3.2.1.2	<i>Methodological issues (6.B.2 Wastewater treatment)</i>	516
8.3.2.1.3	<i>Uncertainties and time-series consistency (6.B.2 Wastewater treatment)</i>	517
8.3.2.1.4	<i>Source-specific quality assurance / control and verification (6.B.2 Wastewater treatment)</i>	517

8.3.2.1.5	Source-specific recalculations (6.B.2 Wastewater treatment)	518
8.3.2.1.6	Planned improvements (6.B.2 Wastewater treatment)	518
8.3.2.2	Methane emissions from municipal sludge treatment (6.B.2 Sludge treatment)	518
8.3.2.2.1	Source category description (6.B.2 Sludge treatment)	518
8.3.2.2.2	Methodological issues (6.B.2 Sludge treatment)	519
8.3.2.2.3	Uncertainties and time-series consistency (6.B.2 Sludge treatment)	519
8.3.2.2.4	Source-specific quality assurance / control and verification (6.B.2 Sludge treatment)	520
8.3.2.2.5	Source-specific recalculations (6.B.2 Sludge treatment)	520
8.3.2.2.6	Planned improvements (6.B.2 Sludge treatment)	520
8.3.2.3	Nitrous oxide emissions from municipal wastewater (6.B.2 Nitrous oxide emissions from municipal wastewater)	520
8.3.2.3.1	Source category description (6.B.2 Nitrous oxide emissions from municipal wastewater)	520
8.3.2.3.2	Methodological issues (6.B.2 Nitrous oxide emissions from municipal wastewater)	520
8.3.2.3.3	Uncertainties and time-series consistency (6.B.2 Nitrous oxide emissions from municipal wastewater)	521
8.3.2.3.4	Source-category-specific quality assurance / control and verification (6.B.2 Nitrous oxide emissions from municipal wastewater)	522
8.3.2.3.5	Source-specific recalculations (6.B.2 Nitrous oxide emissions from municipal wastewater)	522
8.3.2.3.6	Planned improvements (6.B.2 Nitrous oxide emissions from municipal wastewater)	523
8.4	WASTE INCINERATION (6.C)	523
8.5	OTHER AREAS (6.D)	523
8.5.1	Other areas – composting facilities (6.D.1)	523
8.5.1.1	Source category description (6.D.1)	523
8.5.1.2	Methodological issues (6.D.1)	523
8.5.1.3	Uncertainties and time-series consistency (6.D.1)	524
8.5.1.4	Source-specific quality assurance / control and verification (6.D.1)	524
8.5.1.5	Source-specific recalculations (6.D.1)	524
8.5.1.6	Planned improvements (6.D.1)	525
8.5.2	Other areas – mechanical-biological waste treatment (MBT) (6.D.2)	525
8.5.2.1	Source category description (6.D.2)	525
8.5.2.2	Methodological issues (6.D.2)	526
8.5.2.3	Uncertainties and time-series consistency (6.D.2)	527
8.5.2.4	Source-specific quality assurance / control and verification (6.D.2)	527
8.5.2.5	Source-specific recalculations (6.D.2)	527
8.5.2.6	Planned improvements (6.D.2)	527
9	OTHER (CRF SECTOR 7)	528
10	RECALCULATIONS AND IMPROVEMENTS	529
10.1	EXPLANATION AND JUSTIFICATION OF THE RECALCULATIONS	529
10.1.1	Greenhouse-gas inventory	529
10.1.1.1	General procedure	529
10.1.1.2	Recalculations in the 2011 report year, by source categories	530
10.1.1.3	Recalculations in the 2011 inventory, by gases	532
10.1.1.4	Recalculations carried out to implement results of the review process	533
10.1.2	KP LULUCF inventory	534
10.1.2.1	General procedure	534
10.1.2.2	Recalculations/recalculations in the 2010 report year, by source categories	534
10.1.2.3	Recalculations in the 2010 inventory, by gases	534
10.1.2.4	Recalculations carried out to implement results of the review process	534
10.2	IMPACT ON EMISSIONS LEVELS	534
10.2.1	Greenhouse-gas inventory	534
10.2.1.1	Impacts on 1990 emissions levels	536
10.2.1.2	Impacts on 2008 emissions levels	537
10.2.2	KP LULUCF inventory	538
10.2.2.1	Impacts on 1990 emissions levels	538
10.2.2.2	Impacts on 2008 emissions levels	539
10.3	IMPACTS ON EMISSIONS TRENDS AND ON TIME-SERIES CONSISTENCY	539
10.3.1	Greenhouse-gas inventory	539
10.3.2	KP LULUCF inventory	539
10.4	INVENTORY IMPROVEMENTS	539
10.4.1	Greenhouse-gas inventory	539

10.4.2 KP & LULUCF	550
10.5 RECALCULATIONS AS A RESULT OF THE IN-COUNTRY REVIEW 2010	550
10.5.1 Recalculations carried out as a result of the In-Country Review 2010: impacts on the overall inventory for 2010	550
10.5.2 Findings of the ERT described in the Saturday Letter, and the resulting recalculations	556
10.5.2.1 Combustion of fuels – Other – Blast furnace gas (1.A.2.f)	556
10.5.2.2 Venting and flaring (1.B.2.c)	556
10.5.2.3 Emissions from national coastal and inland shipping – here: emissions decrease as of 2007 (1.A.3.d)	557
10.5.2.4 Emissions from fisheries – here: emissions from German deep-sea fishing (1.A.4.c iii)	557
10.5.2.5 Emissions from industrial processes – Mineral products – lime production (2.A.2)	557
10.5.2.6 Emissions from industrial processes – Mineral products – soda ash production and use (2.A.4)	558
10.5.2.7 Emissions from the chemical industry: Ammonia production (2.B.1)	558
10.5.2.8 Emissions from the chemical industry: Nitric acid production (2.B.2)	558
10.5.2.9 4.A.1	559
10.5.2.10 4.B.1	559
10.5.2.11 Indirect N ₂ O emissions from agricultural soils, as a result of leaching and surface runoff (4.D.3.2)	560
10.5.2.12 Managed disposal in landfills – landfilling of municipal waste (6.A.1)	560
11 SUPPLEMENTARY INFORMATION AS REQUIRED PURSUANT TO ARTICLE 7 (1) OF THE KYOTO PROTOCOL	562
11.1 GENERAL INFORMATION	562
11.1.1 The definition of "forest", and other criteria	562
11.1.2 Selected activities under Article 3 (4) of the Kyoto Protocol	562
11.1.3 Description of ways in which the definitions of all activities pursuant to Article 3.3, and of all selected activities pursuant to Article 3.4, have been implemented and applied in a constant manner over time	563
11.1.4 Description of the priority conditions and/or hierarchy among the activities pursuant to Article 3.4, and description of how those conditions/hierarchy have been constantly applied in determining land classification	564
11.2 AREA-ORIENTED INFORMATION	565
11.2.1 Method used for determining area size pursuant to Article 3.3	565
11.2.2 Method used to develop the land-transition matrix	565
11.2.3 Maps and/or databases for determining the geographic position of areas, and the relevant identification system	566
11.3 ACTIVITY-SPECIFIC INFORMATION	567
11.3.1 Methods for determining carbon-stock changes, greenhouse-gas emissions and estimated reductions	567
11.3.1.1 Description of methods and of the relevant applied and underlying assumptions	567
11.3.1.1.1 Biomass	567
11.3.1.1.2 Dead wood	567
11.3.1.1.3 Forest-floor litter and mineral soils	568
11.3.1.1.4 Mineral soils	568
11.3.1.1.5 Organic soils	569
11.3.1.1.6 Other greenhouse-gas emissions from forests	569
11.3.1.2 Justification for non-consideration of a given carbon pool or of greenhouse-gas emissions / reductions in connection with activities pursuant to Article 3.3 and selected activities pursuant to Article 3.4	569
11.3.1.3 Information as to whether indirect or natural greenhouse gases and reductions were excluded	570
11.3.1.4 Changes in data and methods since the last submission (recalculations)	570
11.3.1.5 Estimation of uncertainties	571
11.3.1.6 Information about other methods	571
11.3.1.6.1 Comparison with results of other countries	571
11.3.1.7 The initial year of an activity, if after 2008	573
11.4 ARTICLE 3.3	574
11.4.1 Information proving that activities pursuant to Article 3.3 began on or after 1 January 1990, and prior to 31 December 2012, and are directly human-induced	574
11.4.2 Information about the distinction between a) harvest or forest disturbance that is followed by new forest formation and b) deforestation	574

11.4.3 Information about the size and geographic position of forest lands that have lost their forest cover but are not considered deforested	574
11.5 ARTICLE 3.4	575
11.5.1 Information proving that activities pursuant to Article 3.4 began after 1 January 1990 and are human-caused	575
11.5.2 Information relative to management of cultivated areas and pastures, and to grassland restoration, if selected, for the base year	575
11.5.3 Information on forest management	575
11.6 FURTHER INFORMATION	575
11.6.1 Key-source analysis for activities pursuant to Article 3.3, and for selected activities pursuant to Article 3.4	575
11.7 INFORMATIONEN ZU ARTIKEL 6 (JI- & CDM-PROJEKTE / MANAGEMENT DER ERU)	575
12 INFORMATION RELATIVE TO ACCOUNTING FOR KYOTO UNITS	576
12.1 BACKGROUND INFORMATION	576
12.2 SUMMARY OF INFORMATION REPORTED IN THE SEF TABLES	576
12.3 DISCREPANCIES AND NOTIFICATIONS	576
12.3.1 Discrepant transactions	576
12.3.1.1 12.3.1.1 15/CMP.1 Annex I.E paragraph 12	576
12.3.2 Reversal of storage information	576
12.3.2.1 15/CMP.1 Annex I.E paragraph 13	576
12.3.3 Non-certification notifications	576
12.3.3.1 15/CMP.1 Annex I.E paragraph 14	576
12.3.4 Non-replacement notifications	577
12.3.4.1 15/CMP.1 Annex I.E paragraph 15	577
12.4 PUBLICLY ACCESSIBLE INFORMATION	577
12.4.1 15/CMP.1 Annex II.E Paragraph 32.(g)	577
12.4.2 13/CMP.1 Annex II Paragraph 45	577
12.4.3 13/CMP.1 Annex II Paragraph 46	577
12.4.4 13/CMP.1 Annex II Paragraph 47	577
12.5 CALCULATION OF THE COMMITMENT PERIOD RESERVE	578
13 INFORMATION ON CHANGES IN THE NATIONAL SYSTEM	580
14 INFORMATION ON CHANGES IN THE NATIONAL REGISTRIES	581
14.1 CHANGE TO THE DATABASE OR THE CAPACITY OF NATIONAL REGISTRY	581
14.1.1 15/CMP.1 Annex I.E paragraph 17	581
14.2 CHANGE TO THE DATABASE OR THE CAPACITY OF NATIONAL REGISTRY	581
14.2.1 15/CMP.1 Annex II.E Paragraph 32.(c)	581
14.2.1.1 New user roles	581
14.2.1.2 Confidential information of account representatives	582
14.2.1.3 Restricted transactions to national accounts	582
14.3 CHANGE OF CONFORMANCE TO TECHNICAL STANDARDS	582
14.3.1 15/CMP.1 Annex II.E Paragraph 32.(d)	582
14.4 CHANGE OF DISCREPANCIES PROCEDURES	582
14.4.1 15/CMP.1 Annex II.E Paragraph 32.(e)	582
14.5 CHANGE OF SECURITY	582
14.5.1 15/CMP.1 Annex II.E Paragraph 32.(f)	582
14.5.1.1 User information at a successful login	582
14.5.1.2 User information at login behaviour	583
14.5.1.3 User information at transaction status	583
14.5.1.4 Additional authorised representative	583
14.5.1.5 Technical administrator	583
14.5.1.6 Automated interface	583
15 INFORMATION REGARDING MINIMISATION OF NEGATIVE IMPACTS PURSUANT TO ARTICLE 3 (14)	584
16 FURTHER INFORMATION	586
17 ANNEX 1: GERMAN GREENHOUSE GAS INVENTORY - KEY SOURCES	587
17.1 DESCRIPTION OF THE METHOD FOR IDENTIFYING KEY SOURCES	588
17.1.1 Tier 1 approach	588
17.1.2 Tier 2 approach	588

17.1.3 Key-source analysis for Kyoto reporting	588
18 ANNEX 2: DETAILED DISCUSSION OF THE METHODOLOGY AND DATA FOR CALCULATING CO₂ EMISSIONS FROM COMBUSTION OF FUELS	590
18.1 THE GERMAN ENERGY BALANCE	590
18.2 STRUCTURE OF THE ENERGY BALANCES	591
18.3 METHODOLOGICAL ISSUES: ENERGY-RELATED ACTIVITY DATA	596
18.4 UNCERTAINTIES AND TIME SERIES CONSISTENCY IN THE ENERGY BALANCE	597
18.4.1 The balance year 1990 and the Energy Balances for 1991 to 1994	598
18.5 UNCERTAINTIES IN THE ACTIVITY DATA FOR STATIONARY COMBUSTION SYSTEMS	599
18.6 CO ₂ EMISSION FACTORS	599
18.6.1 Preliminary remarks on methods	599
18.6.2 Basic emission factors for CO ₂	600
18.6.3 Determination of inventory emission factors for CO ₂	600
18.7 ANALYSIS OF CO ₂ EMISSIONS FROM NON-ENERGY-RELATED USE OF FUELS	607
19 ANNEX 3: OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES, INCLUDING KP-LULUCF ACTIVITIES	611
19.1 OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR THE SOURCE CATEGORY "ENERGY" (1)	611
19.1.1 Revision of the activity data for stationary combustion systems of the new German Länder for the year 1990 and for subsequent years (1.A.1 and 1.A.2)	611
19.1.2 Energy Industries (1.A.1)	611
19.1.2.1 Methodological aspects of determination of emission factors (Chapter 3.2.6.2)	611
19.1.2.2 Methane emission factor in the research project RENTZ et al, 2002	615
19.1.2.3 CO ₂ emissions from flue-gas desulphurisation (CRF 1.A.1, Limestone balance)	615
19.1.3 Transport (1.A.3)	616
19.1.3.1 Transport – Civil aviation (1.A.3.a)	616
19.1.3.1.1 Derivation of additional emission factors (1.A.3.a)	616
19.1.3.1.2 Detailed overview of the uncertainties underlying the pertinent activity data and emission factors (1.A.3.a)	620
19.1.3.2 Derivation of activity data for road transport (1.A.3.b)	621
19.1.3.2.1 Harmonisation with the Energy Balance	621
19.1.3.2.2 Allocation of biofuels, petroleum, natural gas and LP gas to the structural elements	623
19.1.3.2.3 Activity data for evaporation	624
19.1.3.3 Derivation of emission factors	624
19.1.3.3.1 Emission factors from TREMOD	624
19.1.3.3.2 Emission factors for biodiesel, bioethanol, petroleum and LP gas	624
19.1.3.4 Derivation of data for western and eastern Germany, 1994	625
19.2 OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR THE SOURCE CATEGORY "INDUSTRIAL PROCESSES" (2)	625
19.2.1 Mineral products (2.A)	625
19.2.2 Chemical industry (2.B)	625
19.2.3 Metal production (2.C)	625
19.2.4 Other production (2.D)	625
19.2.4.1 Pulp and paper (2.D.1)	625
19.2.4.1.1 Fibre-production processes	626
19.2.4.1.2 Paper and carton production	629
19.3 OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR THE SOURCE CATEGORY "SOLVENTS AND OTHER PRODUCT USE" (3)	630
19.4 OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR THE SOURCE CATEGORY "AGRICULTURE" (4)	630
19.4.1 On use of the IPCC Guidelines 2006	630
19.5 OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR THE SOURCE/SINK CATEGORY "LAND-USE CHANGE AND FORESTRY" (5)	637
19.5.1 Forest land (5.A)	637
19.5.1.1 Further information about the project GSE Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT)	637
19.5.1.1.1 Definition of forest land and land-use categories	637
19.5.1.1.2 Data sources, data processing and evaluation, precision analysis	637
19.5.1.1.3 Adaptation of the results of the GSE FM-INT project	638
19.5.1.2 Uncertainties and time-series consistency	640

19.5.1.2.1 Error budget	640
19.5.1.3 Forest Land converted to Other Land	644
19.5.1.3.1 Source category description	644
19.5.1.3.2 Stock losses on forest land converted to other land	644
19.5.1.4 Supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol	645
19.5.1.4.1 Requirements pertaining to forest management, and forest planning, pursuant to the Federal Forest Act (BWaldG) and state forest acts (Landeswaldgesetze; LWaldG)	645
19.5.1.4.2 Comparison of international and national definitions of forest management	649
19.5.2 Cropland, grassland, wetlands, settlements and other areas (5.B/5.C/5.D/5.E/5.F)	650
19.5.2.1 Land-area distribution and allocation of usage categories	650
19.5.2.1.1 Procedures	650
19.5.2.1.1.1 Sampling inventory	650
19.5.2.1.1.2 Wall-to-wall approach	650
19.5.2.1.1.3 Data sources and their adaptation	650
19.5.2.1.1.4 Inconsistencies and system change	652
19.5.2.1.1.5 Reconstruction of land use in 1990	653
19.5.2.1.2 Determination of land-use changes, and of use-change-related area shifts	653
19.5.2.1.3 Areas of organic soils	657
19.5.2.2 Determination of carbon stocks, and of their changes as a result of land-use changes	658
19.5.2.3 Changes in carbon stocks in the soil and in biomass	658
19.5.2.3.1 Derivation of EF for mineral soil as a result of land-use changes	658
19.5.2.3.2 Derivation of calculation figures (emission factors) for biomass	660
19.5.2.3.2.1 Forest, permanent cultivations, wetlands and groves within settled areas	660
19.5.2.3.2.2 Grassland and non-perennial crops:	660
19.5.2.4 Liming	663
19.5.2.5 Determination of N ₂ O emissions following conversion to cropland	664
19.5.2.6 Planned improvements	664
19.5.2.7 Action plan for resolving issues identified by the ERT regarding KP LULUCF	665
19.6 OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR THE SOURCE CATEGORY	
"WASTE AND WASTEWATER" (6)	672
19.6.1 Solid waste disposal on land (6.A)	672
19.6.1.1 Uncertainties for the source category "solid waste disposal on land"	672
19.6.2 Wastewater (6.B) – Data for determination of emission factors for wastewater and sewage-sludge treatment (6.B.2)	674
19.6.3 Determination of nitrous oxide emissions from wastewater treatment (6.B.2)	674
20 ANNEX 4: CO₂ REFERENCE APPROACH; COMPARISON OF THAT APPROACH WITH THE SECTORAL APPROACH; AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE	675
21 ANNEX 5: ASSESSMENT OF COMPLETENESS, AND ASSESSMENT OF POTENTIALLY EXCLUDED SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS	676
22 ANNEX 6: ADDITIONAL INFORMATION TO BE CONSIDERED AS PART OF THE NIR SUBMISSION (WHERE RELEVANT) OR OTHER USEFUL REFERENCE INFORMATION	681
22.1 ADDITIONAL INFORMATION RELATIVE TO INVENTORY PREPARATION AND TO THE NATIONAL SYSTEM	681
22.1.1 Definitions in the "National System" principles paper on emissions reporting	681
22.1.2 Additional information about the Quality System of Emissions Inventories	684
22.1.2.1 Minimum requirements pertaining to a system for quality control and assurance	684
22.1.2.1.1 Introduction	684
22.1.2.1.2 System for quality control and quality assurance	685
22.1.2.1.3 Agency responsible for co-ordinating QC/QA activities	685
22.1.2.1.4 QC/QA plan	686
22.1.2.1.5 General quality control	686
22.1.2.1.6 Source-category-specific quality control	687
22.1.2.1.7 Quality assurance procedures	688
22.1.2.1.8 Reporting procedures	688
22.1.2.1.9 Documentation and archiving	688
22.1.2.1.10 Annex 1: Minimum requirements pertaining to quality control and quality assurance in emissions reporting in the Federal Environment Agency	690
22.1.2.1.10.1 Introduction	690
22.1.2.1.10.2 System for quality control and quality assurance	690

22.1.2.1.10.2.1	Agency responsible for co-ordinating QC/QA activities in the Federal Environment Agency	690
22.1.2.1.10.2.2	Reporting procedures	691
22.1.2.1.10.3	QC plan, QA plan and inventory plan	693
22.1.2.1.10.4	Procedures for general and source-category-specific quality control	695
22.1.2.1.10.5	Quality assurance procedures	695
22.1.2.1.10.6	Documentation and archiving	696
22.1.2.1.11	Annex 2: Example of a general checklist for the responsible-expert role	697
22.1.3	The database system for emissions – Central System of Emissions	701
22.2	SUPPLEMENTARY INFORMATION AS REQUIRED PURSUANT TO ARTICLE 7 (1) OF THE KYOTO PROTOCOL	702
22.2.1	KP-LULUCF	702
22.2.2	Standard Electronic Format (SEF) Tables	703
22.2.2.1	Standard Electronic Format for the reported year 2008	703
22.2.3	More detailed information about the national system, and about changes in the national system	706
22.2.4	Additional detailed information regarding the National Registries and accounting (bookkeeping) for Kyoto units	707
22.2.4.1	LIST OF TRANSACTIONS FORWARDING CER FROM THE CDM REGISTRY TO ACCOUNTS IN THE GERMAN REGISTRY	707
22.2.4.2	LIST OF RECONCILIATION RESULTS	709
22.2.4.3	SCREENSHOTS OF PUBLICLY AVAILABLE INFORMATION	715
22.2.4.4	List of publicly available information for each account	723
22.3	ADDITIONAL INFORMATION ABOUT TRENDS FOR GREENHOUSE GASES	724
23	ANNEX 7: TABLE 6.1 OF THE IPCC GOOD PRACTICE GUIDANCE	730
24	REFERENCES	736

List of Figures

Figure 1:	Development of greenhouse gases in Germany since 1990, by greenhouse gases'	55
Figure 2:	Emissions trends in Germany since 1990, by source categories'	58
Figure 3:	Relative development of greenhouse-gas emissions since 1990, by source categories	59
Figure 4:	Structure of the National System of Emissions (NaSE)	64
Figure 5:	NaSE – Objectives and instruments	66
Figure 6:	Overview of the emissions-reporting process	71
Figure 7:	QSE – Roles, responsibilities and workflow	81
Figure 8:	NaSE & QSE – Control and documentation.....	82
Figure 9:	Procedural flow for annual inventory verification using ETS monitoring data	85
Figure 10:	Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector.....	86
Figure 11:	Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes	90
Figure 12:	Responsibilities and data flows for calculation of greenhouse-gas emissions from use of solvents and other products	92
Figure 13:	Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture	93
Figure 14:	Data flows for calculation of greenhouse-gas emissions from the areas of land-use changes and forestry (LULUCF) and KP-LULUCF	94
Figure 15:	Data flows for calculation of greenhouse-gas emissions from the area of waste and wastewater	96
Figure 16:	Relative development of greenhouse gases in comparison to their levels in 1990	113
Figure 17:	Relative development of F gases in comparison to relevant 1995 levels	116
Figure 18:	Emissions trends for indirect greenhouse gases and SO ₂	119
Figure 19:	Overview of greenhouse-gas emissions in CRF sector 1	121
Figure 20:	Characteristics of the Federal Environment Agency's structure of the Balance of Emission Causes, for disaggregation of the Energy Balance	125
Figure 21:	CO ₂ emissions in Germany – comparison of results of national and international calculations.....	134
Figure 22:	CO ₂ emissions in Germany – comparison of relative discrepancies of national and international calculations	134
Figure 23:	Development of greenhouse-gas emissions of international air traffic departing from Germany, 1990 - 2009	138
Figure 24:	Development of greenhouse-gas emissions in international maritime transports, 1990 – 2009.....	141
Figure 25:	Development of CO ₂ emissions in source category 1.A.1.a	144
Figure 26:	Development of CO ₂ emissions in source category 1.A.1.b	153
Figure 27:	Development of CO ₂ emissions in source category 1.A.1.c.....	157
Figure 28:	Development of CO ₂ emissions in source category 1.A.2.a	163
Figure 29:	Development of fuel inputs in source category 1.A.2.f [y axis: fuel inputs in TJ; x axis: year; Legend: Gases; Solid fuels; Liquid fuels; Biomass; Other fuels]	171
Figure 30:	Development of greenhouse-gas emissions in national air transports, 1990 – 2009.....	184

Figure 31:	Revised split factor for national/international air traffic, 1990-2009	186
Figure 32:	Development of greenhouse-gas emissions from railway transports, 1990-2009 (not including emissions from generation of electric power for railways).....	198
Figure 33:	Development of greenhouse-gas emissions in inland shipping, 1990 – 2009	202
Figure 34:	Change in total emissions of 1.A.4, as a function of temperature [y axis: left: CO ₂ in millions of t; right: degree days; top: Degree days in Germany, and CO ₂ emissions of 1.A.4 "Other"; CO ₂ emissions; Degree days; x axis: year].....	212
Figure 35:	Trends in energy consumption in 1.A.4, for 4 fuel categories [y axis: Energy consumption in PJ; x axis: year; top: Development of energy consumption in source category 1.A.4; Liquid fuels; Gases; Solid fuels; Biomass]	213
Figure 36:	Development of CO ₂ emissions in source category 1.A.5 [y axis: CO ₂ emissions in million t; x axis: year; Gaseous; Liquid; Solid; CO ₂ emissions by fuels].....	220
Figure 37:	Development of greenhouse-gas emissions in military transports, 1990 – 2009	222
Figure 38:	Emissions of CO ₂ , CH ₄ , NMVOC, SO ₂ and CO in source category 1.B.	224
Figure 39:	Comparison of used and emitted CH ₄ from pit gas.....	232
Figure 40:	Overview of greenhouse-gas emissions in CRF Sector 2	258
Figure 41:	Chronological trend and source-category allocation of the CO ₂ emissions resulting from use of reducing agents for primary steel production and from use of top gas.....	298
Figure 42:	Overview of greenhouse-gas emissions in CRF Sector 3	365
Figure 43:	Overview of greenhouse-gas emissions in CRF Sector 4	378
Figure 44:	Logical structure behind national methods for calculating emissions from animal husbandry.....	380
Figure 45:	The GAS-EM model: basic concept, thematic content and spatial resolution	381
Figure 46:	Overview of land-use categories and subcategories, and of data sources, activity data and emission factors in the German LULUCF reporting system.....	443
Figure 47:	Overview of possible land-use changes, as well as of algorithms for estimating the relevant emissions and binding of CO ₂	444
Figure 48:	Emissions development in the LULUCF sector since 1990	444
Figure 49:	Carbon stocks in below-ground and above-ground biomass, in forest, in the years 1987/1993, 2002 and 2008	453
Figure 50:	Regression between carbon stocks (0-30cm) as shown by BZE II / BioSoil data and the BZE I data (left), and outliers identified via residuals analysis with studentised residuals (middle) and "high-leverage" points (right), with regard to the example of the new main soil unit podsol – para-brown earth / podsol – pale earth / pale earth / brown earth from sandy covering layers overlying boulder clay. .	466
Figure 51:	Areas affected by wildfires between 1990 and 2009 (pursuant to BLE, 2010)	469
Figure 52:	Overview of greenhouse-gas emissions in CRF Sector 6	503
Figure 53:	Changes in pathways for management of household waste, 1990 to 2009, with intermediate years.....	505
Figure 54:	Trends in waste composition (old German Länder) between 1980 and 2000	508
Figure 55:	Trends in bulky-waste composition (old German Länder) between 1980 and 2008..	509
Figure 56:	Change in total emissions, for all categories, and for the entire time series, in comparison to the relevant figures in the Resubmission 2010	532
Figure 57:	Recalculations of pollutant-specific total emissions, for all source categories, and for the entire time series, in comparison to the relevant figures in the Resubmission 2010.....	533

Figure 58:	Recalculations of all greenhouse gases for 1990	537
Figure 59:	Recalculations of all greenhouse gases for 2008	538
Figure 60:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 - 2008.....	556
Figure 61:	Commitment Period Holding (CPH) in 2009	579
Figure 62:	Line structure of Energy Balances until 1994 and as of 1995.....	593
Figure 63:	Energy resources in the Energy Balance of the Federal Republic of Germany	595
Figure 64:	Base and inventory emission factors for CO ₂	599
Figure 65:	Methods for calculating emission factors	613
Figure 66:	Map of the state of Thuringia with the land-use categories "afforestation" (yellow), "forest land converted to other land" (red) and "managed forest land" (green)	639
Figure 67:	Responsibilities at, and data flows between, the institutions involved in preparing the submissions for LULUCF and KP-LULUCF. UBA manages final co-ordination on NIR and reporting tables ("departmental co-ordination") following completion of the CSE draft, the CRF tables and the NIR draft. That procedure is not included in the figure.	669
Figure 68:	Overview of the overall emissions-reporting process.....	692
Figure 69:	Control and documentation in the framework of the NaSE and the QSE	694

List of Tables

Table 1:	Emissions trends in Germany, by greenhouse gas and source category	56
Table 2:	Contributions to emissions trends in Germany, by greenhouse gas and source category	57
Table 3:	Global Warming Potential (GWP) of greenhouse gases	78
Table 4:	QSE – Roles and responsibilities	80
Table 5:	Number of source categories and key categories	99
Table 6:	Results of KP-LULUCF key-category assessment	100
Table 7:	Key categories for Germany pursuant to the Tier 1 method	101
Table 8:	Key categories for Germany identified solely via the Tier 2 approach	102
Table 9:	Inventory plan 2010	105
Table 10:	Emissions of direct and indirect greenhouse gases and SO ₂ in Germany since 1990	112
Table 11:	Changes in emissions of direct and indirect greenhouse gases and SO ₂ in Germany, since the relevant reference years	112
Table 12:	Changes in greenhouse-gas emissions in Germany, by source categories, since 1990 / since the relevant previous year	118
Table 13:	Emissions in 2008 and 2009 for the KP-LULUCF activities afforestation and deforestation, pursuant to Article 3.3, and for forest management, pursuant to Article 3.4	120
Table 14:	Structure of the Balance of Emissions Causes – public services – source category 1.A.1.a	126
Table 15:	Structure of the Balance of Emissions Causes – refineries – source category 1.A.1.b	127
Table 16:	Structure of the Balance of Emissions Causes – coal mining and other transformation sector – source category 1.A.1.c	128
Table 17:	Structure of the Balance of Emissions Causes – source categories 1.A.1.a-f	129
Table 18:	Structure of the Balance of Emissions Causes – other industrial power stations and industrial boilers – source category 1.A.2.f Other	130
Table 19:	Structure of the Balance of Emissions Causes – structural elements already integrated within the CSE – source categories 1.A.4 and 1.A.5.a	131
Table 20:	Structure of the Balance of Emissions Causes – natural-gas-compressor stations – source category: 1.A.3.e	131
Table 21:	Comparison of CO ₂ inventories with other independent national and international results for CO ₂ emissions	133
Table 22:	Comparison of the results of CO ₂ calculations of individual Länder with corresponding figures from the federal inventories	136
Table 23:	Development of international air transports' share of total kerosene consumption, since 1990	138
Table 24:	Changes in international air transports' share of total kerosene consumption, 1990-2008	139
Table 25:	Effects of the described recalculations on emissions in source category 1.C.1.a – International air transports, 1990-2008	139
Table 26:	Activity data taken from the Energy Balance (1.C.1.b)	141
Table 27:	CO ₂ emissions from top-gas combustion in public power stations	146
Table 28:	Technological emission factors for nitrous oxide from large combustion systems	148

Table 29:	Technological emission factors for nitrous oxide from systems < 50 MW furnace thermal output.....	148
Table 30:	Recalculations for CO ₂ in CRF 1.A.2.a	165
Table 31:	Inputs of secondary fuels in the pulp and paper industry: CO ₂ emission factors and their biogenic components	168
Table 32:	Inputs of secondary fuels in the cement industry: emission factors and their biogenic components	173
Table 33:	Inputs of substitute fuels in the lime industry: emission factors and their biogenic components	178
Table 34:	Recalculations for CO ₂ in CRF 1.A.2.f Other	182
Table 35:	Development of the national share since 1990 - pursuant to IFEU & ÖKO-INSTITUT 2010	186
Table 36:	Emission factors for avgas (1990-2009)	188
Table 37:	Revision of the split factor for national transports as a share of total transports, 1990-2002	190
Table 38:	Revision of kerosene consumption of total air transports leaving from German airports.....	190
Table 39:	Trends for lubricants co-combusted in category 1.A.3.a, and the resulting CO ₂ emissions (now being reported for the first time) as of 1990	191
Table 40:	Effects of described revisions of the inventory on reported greenhouse-gas emissions, 1990-2008	191
Table 41:	Emissions from road transports.....	193
Table 42:	Differentiation of emissions-control categories in road transports	194
Table 43:	Recalculated greenhouse-gas emissions for road transports.....	196
Table 44:	Sources for AD in 1.A.3.c	198
Table 45:	Comparison of EF used and default EF	200
Table 46:	Recalculated activity data (1.A.3.c).....	201
Table 47:	Comparison of the EF(CH ₄) used last year and this year (1.A.3.c)	201
Table 48:	Trends for lubricants co-combusted in category 1.A.3.c, and the resulting CO ₂ emissions (now being reported for the first time) as of 1990	201
Table 49:	Effects of recalculations on total greenhouse-gas emissions in the source category, since 1990, except for CO ₂ emissions from biodiesel (1.A.3.c)	201
Table 50:	Effects of recalculations on CO ₂ emissions from Biodiesel, 2006 (1.A.3.c).....	201
Table 51:	Sources for AD in 1.A.3.d	203
Table 52:	Trends for lubricants co-combusted in category 1.A.3.d, and the resulting CO ₂ emissions (now being reported for the first time) as of 1990	205
Table 53:	Comparison of the EF(CH ₄) used last year and this year	206
Table 54:	Changes as a result of the transition from calculated values to Energy Balance values	206
Table 55:	Effects of recalculations on total greenhouse-gas emissions in the source category, since 1990, except for CO ₂ emissions from biodiesel	206
Table 56:	Effects of recalculations on CO ₂ emissions from biodiesel. 2006	206
Table 57:	EF(CH ₄) for construction-sector transports as of 1990, as brought into line with the revised TREMOD-MM model (in [kg/TJ])	210
Table 58:	Comparison of construction-sector methane emissions, 1990-2008, as reported last year and as reported this year	210

Table 59:	Comparison of construction-sector greenhouse emissions, 1990-2008, as reported last year and as reported this year	210
Table 60:	Sectoral emission factors for combustion systems in the residential and commercial/institutional sectors for reference year 2005.....	216
Table 61:	Sectoral emission factors for mobile sources of the residential, agricultural- transports and fisheries sectors	216
Table 62:	Emissionsberechnung mit landesspezifischen Tier 2/3 Emissionsfaktoren und mit den Tier 1 Default-Emissionsfaktoren nach (IPCC 2006)	218
Table 63:	Sectoral emission factors for the military sector.....	221
Table 64:	Trends for lubricants co-combusted in category 1.A.5.b, and the resulting CO ₂ emissions (now being reported for the first time) as of 1990	222
Table 65:	Impacts on total emissions reported in 1.A.5.b	223
Table 66:	Allocation of methane emissions to areas of the CRF	225
Table 67:	Calculation of methane emissions from coal mining for 2009.....	226
Table 68:	Emission factors for CH ₄ from coal mining, for 2009	229
Table 69:	Recalculations for carbon dioxide and methane in source category 1.B.2	235
Table 70:	Activity data for calculation of emissions in 1.B.2.a.v.....	242
Table 71:	Emission factors for petrol fuels during refuelling and transfer/storage	243
Table 72:	The gas-distribution network (1.B.2.b.iii and 1.B.2.b.iv) and the methane emissions it causes	250
Table 73:	Structure of the gas-distribution network.....	251
Table 74:	Production and CO ₂ emissions in the German cement industry	260
Table 75:	Production and CO ₂ emissions in the German lime industry	263
Table 76:	Limestone balance sheet for use of limestone in areas with, and without, relevance with regard to carbon-dioxide emissions	266
Table 77:	Comparison of balance-sheet positions with emissions relevance pursuant to GL 1996 (report category 2.A.3), for 2008, as gained from model calculations with specific key figures ("from key figures") and from statistical information ("statistical")	268
Table 78:	Activity data and use-related CO ₂ emissions since 1990.....	270
Table 79:	Production and laying of roof and sealing sheeting with bitumen, and relevant activity data and emission factors	273
Table 80:	Emission factors for production of mixed asphalt products.....	275
Table 81:	Activity data and process-related CO ₂ emissions since 1990.....	276
Table 82:	Glass: Activity data for the various industry sectors (types of glass)	277
Table 83:	Cullet percentages for the various types of glass	277
Table 84:	CO ₂ -emission factors for various glass types (calculated in comparison with figures from the CORINAIR manual).....	278
Table 85:	Activity data and process-related CO ₂ emissions in the ceramics industry (CRF 2.A.7.b)(rounded).....	280
Table 86:	IPCC default emission factors for CH ₄ from other chemical industry processes	292
Table 87:	National emission factors for CH ₄ from other chemical industry processes	292
Table 88:	Emission factors used in Germany for other pollutants	293
Table 89:	Reporting numbers (Meldenummern) from production statistics	293
Table 90:	Recalculation of CO ₂ emissions from methanol production (2.B.5)	295
Table 91:	CO ₂ emissions from primary steel production (including top-gas use)	298
Table 92:	Limestone inputs and resulting CO ₂ emissions in sinter and pig iron production	299

Table 93:	Total process-related emissions to be reported under 2.C.1	300
Table 94:	Recalculation of process-related CO ₂ emissions, from iron and steel production, reported under 2.C.1	302
Table 95:	Source-specific recalculations - Ferroalloys production (2.C.2).....	303
Table 96:	Activity data and process-related emission factors for primary aluminium production in 2009.....	305
Table 97:	IPCC default emission factors for SO ₂ , NO _x CO and NMVOC from pulp production.....	311
Table 98:	Real emission factors, for German plants, from pulp production. (German contribution to revision of the BAT reference (BREF) document for the pulp and paper industry, 2007).....	311
Table 99:	Pulp and paper production, produced quantities.....	311
Table 100:	NMVOC emissions from the food industry (2.D.2).....	314
Table 101:	Overview of methods and emission factors used for the current report year, in source category 2.F - <i>Consumption of halocarbons and SF₆</i>	319
Table 102:	Overview of recalculation-related changes in activity data (AD) and emissions (EM) for use and disposal of HFC-134a in large stationary air conditioners in source category 2.F.1.e.	332
Table 103:	Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production and use of HFC-125, HFC-134a, HFC-143a and HFC-32 in heat pumps in source category 2.F.1.e.	334
Table 104:	Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production, use and disposal of HFC-134a in bus air conditioners in source category 2.F.1.f.	336
Table 105:	Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production, use and disposal of HFC-134a in agricultural-machinery air conditioning systems in source category 2.F.1.f.....	337
Table 106:	Overview of recalculation-related changes in activity data (AD), emission factors (EF) and emissions (EM) for production and use of HFC-134a in ship air conditioning systems in source category 2.F.1.f.....	338
Table 107:	Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production, use and disposal of HFC-134a in utility-vehicle air conditioning systems in source category 2.F.1.f.....	339
Table 108:	Overview of recalculation-related changes in production emissions (EM), and in activity data (AD), emission factors (EF) and emissions (EM) for use of HFC-134a in railway-vehicle air conditioning systems in source category 2.F.1.f.....	340
Table 109:	2009 inventory data for source category 2.F.7, including relevant sub- source categories	353
Table 110:	Overview of the recalculation-related changes in activity data (AD), emissions (EM) and emission factors (EF) for SF ₆ , NF ₃ and CF ₄ in production of photovoltaic cells in source category 2.F.8.h.	362
Table 111:	Overview of the recalculation-related changes in the activity data (AD) and emissions (EM) for SF ₆ in source category 2.F.8.a – sound-proof glazing.	363
Table 112:	Source-specific recalculations, in 3.A-D, for NMVOC emissions from solvents	369
Table 113:	Source-specific recalculations, in 3.A-D, for CO ₂ equivalents of solvent emissions..	370
Table 114:	Recalculation for explosives.....	376
Table 115:	Recalculation of laughing-gas emissions from narcotic uses	376

Table 116:	Characterisation of animal stocks pursuant to IPCC, and the pertinent breakdown used for purposes of German emissions reporting	383
Table 117:	Animal-place figures used in German reporting (4.A, 4.B)	386
Table 118:	Mean animal weights (4.B).....	387
Table 119:	Mean daily milk yield for dairy cows (kg/day) (4.A)	387
Table 120:	Mean pregnancy rates (4.A).....	388
Table 121:	Mean daily gross energy intake (GEI) (4.A)	388
Table 122:	Feed digestibility (4.A)	388
Table 123:	Total-uncertainties calculation for emissions from Sector 4 (animal husbandry and use of agricultural soils).....	391
Table 124:	Methane-conversion factor (4.A)	396
Table 125:	CH ₄ emissions E _{CH₄} from animal husbandry (enteric fermentation) (4s1.A)	397
Table 126:	CH ₄ emissions from enteric fermentation (4.A.1.a).....	397
Table 127:	CH ₄ emissions from animal husbandry (enteric fermentation) (4.A.1.a).....	398
Table 128:	CH ₄ emission factors (enteric fermentation) for "other cattle", for 2009, in comparison with the default values for western Europe pursuant to IPCC (1996b)-4.11, Table 4-4 and IPCC (2006)-10.29, Table 10.11	398
Table 129:	The emission factors (enteric fermentation) used in the inventory for sheep, goats, large horses, small horses and ponies, mules and asses and buffalo.....	398
Table 130:	Methane emissions from enteric fermentation in dairy cows, in various countries – a comparison of Implied Emission Factors (IEF); figures for Germany for 2009; data of other countries for 2008.	399
Table 131:	Comparison of resulting CH ₄ emission factors as reported in 2011 and in 2010 (4.A)	400
Table 132:	Comparison of CH ₄ emissions (enteric fermentation) as reported in 2011 and in 2010 (4.A).....	400
Table 133:	Daily VS excretions per animal, for dairy cows, other cattle, swine and poultry (not including geese) (4.B(a)s1)	403
Table 134:	Daily VS excretions per animal place, for sheep, goats, horses, mules and asses, buffalo and poultry (not including geese) (4.B(a)s1)	404
Table 135:	Maximum methane-formation capacity B ₀ , pursuant to IPCC (2006)-10.77ff (4.B(a)s1).....	404
Table 136:	Maximum methane-formation capacity B ₀ for poultry (4.B(a)s1)	404
Table 137:	Relative shares of liquid-manure-based systems, in % of excreted N (4.B(a)s2).....	405
Table 138:	Relative shares of straw--based systems, in % of excreted N (4.B(a)s2).....	405
Table 139:	Grazing: relative shares of housing systems, in % of excreted N (4.B(a)s2).....	406
Table 140:	Methane-conversion factors (MCF) for liquid-manure-based systems for dairy cows, other cattle and swine (4.B(a)s2)	406
Table 141:	Total CH ₄ emissions from manure management (4s1)	407
Table 142:	CH ₄ emissions from manure management for dairy cows, other cattle and swine (4.s1.)	407
Table 143:	CH ₄ emission factors (IEF) for manure management (4.B(a)s1)	407
Table 144:	Methane emissions from storage of farm manure from dairy cows, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)	408

Table 145:	Methane emissions from storage of farm manure from other cattle, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)	409
Table 146:	Methane emissions from storage of farm manure from swine, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)	409
Table 147:	Methane emissions from storage of farm manure from poultry, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)	410
Table 148:	Comparison of the relative shares of liquid-manure-based systems, as reported in 2011 and 2010, in % of excreted N (4.B(a)s2)	411
Table 149:	Comparison of the relative shares of straw-based systems, as reported in 2011 and 2010, in % of excreted N (4.B(a)s2)	412
Table 150:	Comparison of the relative shares of for grazing, as reported in 2011 and 2010, in % of excreted N (4.B(a)s2)	413
Table 151:	Comparison of daily VS excretions per animal, as reported in 2011 and as reported in 2010, for dairy cows, other cattle and swine (4.B)	414
Table 152:	Comparison of CH ₄ emission factors (IEF), as reported in 2011 and as reported in 2010, for manure management (4.B(a)s1)	414
Table 153:	Comparison of CH ₄ emissions, as reported in 2011 and as reported in 2010, for dairy cows, other cattle and swine (4.B)	415
Table 154:	NMVOC emissions E_{NMVOC} from animal husbandry (manure management), given as NMVOC and NMVOC-C (4s1.B, 4s2.B)	416
Table 155:	NMVOC emissions from animal husbandry (manure management), (4s1.B, 4s2.B)	417
Table 156:	N excretions per animal place and year (4.B(b))	420
Table 157:	Total annual N excretions for liquid-manure-based systems (4.B(b))	421
Table 158:	Total annual N excretions for straw-based systems (4.B(b))	421
Table 159:	Total annual N excretions during grazing (4.B(b))	422
Table 160:	N ₂ O emissions from manure management, by animal categories (4.B)	422
Table 161:	N ₂ O emissions from manure management, by management systems (4.s2.B)	423
Table 162:	NO emissions (E_{NO}) from manure management	423
Table 163:	Partial emission factors for N ₂ O, NO and N ₂ emissions from manure storage (with regard to excreted N) (4.B(b))	424
Table 164:	N excretions per animal place, for dairy cows, other cattle, swine and poultry, in various countries (in Germany, for 2009; in other countries, for 2008)	425
Table 165:	Comparison of N excretions per animal place as reported in 2011 and as reported in 2010 (4.B)	426
Table 166:	Comparison of total N excretions of all animals, as calculated in 2011 and as calculated in 2010 (in Gg a ⁻¹)	427
Table 167:	Comparison of N ₂ O emissions from manure management, as reported in 2011 and as reported in 2010, by systems (4.s2.)	427
Table 168:	Comparison of NO emissions (E_{NO}) from manure management, as reported in 2011 and as reported in 2010	427

Table 169:	Emission factors EF_{NO} für NO emissions from agricultural soils	432
Table 170:	N quantities on which calculation of direct N ₂ O emissions is based (4.Ds1.1.1 through 4.Ds1.1.4).....	434
Table 171:	Area of cultivated organic soils, in the NIR 2011 and in the Resubmission 2010, on which calculation of direct N ₂ O emissions is based (4.Ds1.1.5)	434
Table 172:	Sums, as calculated for the inventory, of NH ₃ and NO emissions from German agriculture that serve as a basis for calculation of deposition-related indirect N ₂ O emissions.....	434
Table 173:	Reactive nitrogen N _{reac} upon which calculation of N ₂ O emissions is based (4.Ds1.3.1)	434
Table 174:	Leached-out quantity of N (including surface runoff) (4.Ds1.3.2)	435
Table 175:	$Frac_{GASF}$ (4.Ds2)	435
Table 176:	$Frac_{GASM, Germany}$ (4.Ds2).....	435
Table 177:	$Frac_{GRAZ}$ (4.Ds2)	435
Table 178:	$Frac_{NCRBF}$ (4.Ds2)	435
Table 179:	$Frac_{NCR0}$ (4.Ds2)	435
Table 180:	$Frac_R$ ($Frac_{Remove}$) (4.Ds2).....	435
Table 181:	N ₂ O and NO emissions E_{N_2O} and E_{NO} from agricultural soils (4s1, 4s2).....	436
Table 182:	Indirect N ₂ O emissions resulting from deposition of reactive N species, as calculated for the NIR 2011	436
Table 183:	NMVOC emissions from crop cultivation and grassland (4s1.D, 4s2.D).....	436
Table 184:	Comparison of the N ₂ O emission factors used in the German inventory with those of neighbouring countries (those of Germany, for reference year 2009; those of other countries, for 2008)	437
Table 185:	Comparison of the $Frac$ values used in the German inventory with those of neighbouring countries (those of Germany, for 2009; those of other countries, for 2008)	437
Table 186:	Comparison of N quantities, as reported in 2010 and as reported in 2011, used to calculate N ₂ O emissions from agricultural soils (4.D)	439
Table 187:	Comparison of N ₂ O emissions from agricultural soils as reported in 2010 and as reported in 2011 (4.D).....	440
Table 188:	Forest area, forest land remaining forest land and conversions from other land-use categories to new forest land, in the old German Länder, from 1990 through 2009.....	450
Table 189:	Annual rates of conversion from forest land to other land-use categories, in the old German Länder	450
Table 190:	Forest area, forest land remaining forest land and conversions from other land-use categories to new forest land, in the old German Länder, from 1990 through 2009.....	451
Table 191:	Annual rates of conversion from forest land to other land-use categories, in the new German Länder.....	451
Table 192:	Raw-wood production pursuant to logging statistics of the Federal Statistical Office (Destatis).....	452
Table 193:	Carbon stocks from previous uses	454
Table 194:	Bulk densities rd in [g/cm ³], as given by IPCC (2003), KOLLMANN (1982) and KNIGGE & SCHULZ (1966)	457
Table 195:	Models for deriving volume-expansion factors.....	458

Table 196:	Wood densities for branch wood	458
Table 197:	Root/shoot-ratio at the plantation level, pursuant to IPCC (2003)	459
Table 198:	Carbon stocks in litter in German forests, as determined in the BZE I and BZE II / BioSoil inventories, along with the pertinent standard error.....	463
Table 199:	Emission factors for mineral soils in land-use categories involving conversion to forest land, for the year 2009	464
Table 200:	Combined legend units on the basis of the BÜK 1000 soil map	465
Table 201:	Carbon stocks at the time of the BZE I survey and at the time of the BZE II survey, and annual rates of carbon-stock change, in the newly formed main soil units; and correlated forest areas.....	467
Table 202:	Greenhouse gases emitted as a result of wildfires, in the period 1990-2009	470
Table 203:	N ₂ O emissions from conversion of forest land to cropland	471
Table 204:	Sampling error (SE) in area estimation for LULUCF classes, between 1987 and 2002 (nd = not defined)	472
Table 205:	Sampling error (SE) in area estimation for LULUCF classes between 2002 and 2008.....	472
Table 206:	Relative standard error of volume-expansion models.....	473
Table 207:	Uncertainties arising in the volume expansion.....	473
Table 208:	Relative standard error of bulk-density estimates	474
Table 209:	Uncertainties arising in connection with use of bulk densities	475
Table 210:	Uncertainties arising in use of root/shoot relationships.....	476
Table 211:	Sampling error for above-ground biomass.....	479
Table 212:	Random-sampling error for below-ground biomass	480
Table 213:	Total error in estimation of C stocks and C-stock changes between 1987 and 2002, in the old German Länder.....	481
Table 214:	Total error in estimation of C stocks and C-stock changes between 2002 and 2008 in Germany	481
Table 215:	Carbon-stock changes in living biomass, in various countries (Germany, for 2009; other countries, for 2008)	485
Table 216:	Carbon-stock changes in dead organic mass, in various countries (Germany, for 2009; other countries, for 2008)	485
Table 217:	Carbon-stock changes in mineral soils, in various countries (Germany, for 2009; other countries, for 2008)	486
Table 218:	New recalculation of C storage in biomass, for the category "forest land remaining forest land"	487
Table 219:	Recalculation of C-stock losses in biomass organic soils, for the category "new forest land"	488
Table 220:	Recalculation of C storage in biomass, for the category "new forest land"	488
Table 221:	Recalculation of C storage in litter, for the category "new forest land"	489
Table 222:	Land-use changes matrix for 2008/2009, for Germany	492
Table 223:	Quantities of biodegradable waste landfilled between 2002 and 2009, broken down by waste fractions.....	509
Table 224:	Per-capita quantities of landfilled household waste	510
Table 225:	DOC values used	511
Table 226:	Half-lives and constant methane-production rates of waste fractions.....	512
Table 227:	Methane collection in landfills.....	513
Table 228:	Organic wastewater load in cesspools and septic tanks.....	516

Table 229:	Methane emissions from cesspools and septic tanks	517
Table 230:	Recalculation of CH ₄ emissions from municipal wastewater for the years 2005-2008, and pertinent impacts on greenhouse-gas concentrations	518
Table 231:	Methane emissions from open sludge digestion, in the new German Länder	519
Table 232:	Daily protein intake per person in Germany	521
Table 233:	Population in Germany	521
Table 234:	Nitrous oxide emissions in Germany pursuant to IPCC method	521
Table 235:	Quantities of waste placed in composting facilities	524
Table 236:	Source categories in which new recalculations of the inventory, with regard to last year's report, were required	533
Table 237:	Inventory recalculations with respect to last year's report.....	533
Table 238:	Inventory recalculations, in time series, with respect to last year's report	535
Table 239:	Recalculations of memo-item inventory data provided in addition to data from last year's report.....	536
Table 240:	Recalculation of source-category-specific total emissions, for all gases in 1990	537
Table 241:	Recalculation of source-category-specific total emissions, for all gases in 2008	538
Table 242:	Recalculation of total KP-LULUCF emissions, for all gases in 1990	539
Table 243:	Recalculation of total KP-LULUCF emissions, for all gases in 2008	539
Table 244:	Summary of the improvements documented in the NIR 2011.....	540
Table 245:	Summary of the improvements planned in the source-category chapters.....	544
Table 246:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 - 2008.....	552
Table 247:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on total emissions.....	553
Table 248:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on carbon-dioxide emissions.....	553
Table 249:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on methane emissions (absolute)	554
Table 250:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on methane emissions in CO ₂ equivalents.....	554
Table 251:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on nitrous oxide emissions (absolute)	555
Table 252:	Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on nitrous oxide emissions in CO ₂ equivalents	555
Table 253:	Impacts of inclusion of blast furnace gas losses and flaring on the greenhouse-gas emissions reported under 1.A.2.f Other, 1990-2008	556
Table 254:	Impacts of the described recalculations on the greenhouse-gas emissions reported under 1.B.2.c – Venting and flaring, 1990-2008	556
Table 255:	Impacts of correction of activity data for inland-waterway shipping on the emissions reported under 1.A.3.d, 1990-2008 (not including CO ₂ aus Biodiesel)	557

Table 256:	Impacts of first-time inclusion of emissions of the German deep-sea fishing fleet on the emissions reported under 1.A.4, 1990-2008	557
Table 257:	Recalculation of the CO ₂ emissions of the German lime industry, in the course of the 2010 inventory review	558
Table 258:	Recalculation of CO ₂ emissions from soda-ash use	558
Table 259:	Recalculation of CO ₂ emissions from ammonia production	558
Table 260:	Recalculation of N ₂ O emissions from 2.B.2 – Nitric acid production, 1990-2008	559
Table 261:	Recalculation of CH ₄ emissions from 4.A.1 – Enteric fermentation in dairy cows, 1990-2008	559
Table 262:	Recalculation of CH ₄ emissions from 4.B.1 – Manure management for dairy cows, 1990-2008	560
Table 263:	Recalculation of N ₂ O emissions from 4.D.3.2 – N ₂ O from leaching and surface runoff, 1990-2008	560
Table 264:	Result of the recalculation (6.A.1)	561
Table 265:	Land-use changes from forested land (deforestation), broken down by old German Länder and new German Länder	566
Table 266:	Emission factors for mineral soils of deforestation categories (negative = loss, positive = storage)	568
Table 267:	Emission factors for organic soils of deforestation categories (negative = loss, positive = storage)	569
Table 268:	New calculation of C emissions from biomass of deforested land	570
Table 269:	New calculation of C emissions from litter of deforested land	571
Table 270:	Carbon-stock changes in living biomass (Germany, for 2009; other countries, for 2008)	572
Table 271:	Carbon-stock changes in litter (Germany, for 2009; other countries, for 2008)	573
Table 272:	Carbon-stock changes in dead wood (Germany, for 2009; other countries, for 2008)	573
Table 273:	Carbon-stock changes in mineral soils (Germany, for 2009; other countries, for 2008)	573
Table 274:	Cross-cutting measures	584
Table 275:	Energy-policy measures	584
Table 276:	Agriculture	585
Table 277:	Forestry	585
Table 278:	Waste recycling / treatment	585
Table 279:	KP CRF Table NIR.3: Summary Overview for Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol	589
Table 280:	Data sources for the Energy Balances:	591
Table 281:	Emission factors for CO ₂ as of 1990, as derived for emissions reporting: energy	602
Table 282:	Emission factors for CO ₂ as of 1990, as derived for emissions reporting: industrial processes	606
Table 283:	Verification of completeness of reported CO ₂ from non-energy use of fossil fuels	609
Table 284:	Installation types pursuant to Annex of 4th BImSchV (4th Ordinance on Execution of the Federal Immission Control Act)	614
Table 285:	Classification of sources by type of combustion system	615
Table 286:	Methane emission factors for combustion systems < 50 MW thermal output and for gas turbines, pursuant to RENTZ et al, 2002	615
Table 287:	CO ₂ emissions from flue-gas desulphurisation in public power stations	616

Table 288:	Emission factors for avgas (1990-2009)	618
Table 289:	Overview of emission factors used in the source category Transport – civil aviation (1.A.3.a)	619
Table 290:	Übersicht der zu berücksichtigen Teilunsicherheiten der Aktivitätsraten und Emissionsfaktoren	620
Table 291:	Energy inputs in road transports, 1990-2009	621
Table 292:	Net calorific values for petrol and diesel fuel.....	622
Table 293:	Correction factors for harmonisation with the Energy Balance	623
Table 294:	Emission factors for automobiles that run on LP gas.....	625
Table 295:	Methane emissions from enteric fermentation	631
Table 296:	Methane emissions from manure management.....	632
Table 297:	Satellite data (with relevant survey years), and additional data from the new German Länder for the GSE project (pursuant to GSE 2003, GSE 2006, GSE 2007, GSE 2009).....	638
Table 298:	Total error budget for estimation of biomass C-stocks for the year 1987, in the old German Länder	641
Table 299:	Total error budget for estimation of biomass C-stocks for the year 2002, in the old German Länder	642
Table 300:	Total error budget for biomass-C-stocks changes between 1987 and 2002, in the old German Länder	643
Table 301:	Total error budget for estimation of biomass C stocks and biomass-C-stock changes, in the category Forest Land remaining Forest Land, between 2002 and 2008, in Germany	643
Table 302:	Carbon-stock losses from biomass (including the biomass of the converted land), dead wood, litter and mineral and organic soils, for "forest land converted to other land" as of 2008.....	645
Table 303:	Overview of obligations relative to forest management, preparation of plans and use of forest framework plans, as set forth by the forest acts of the Länder	648
Table 304:	Comparison of forest functions pursuant to the Federal Forest Act and the IPCC	649
Table 305:	Comparison of a) the data sets of the CORINE programme and official statistics, which are available for reconstruction of land use in 1990, and b) the data reconstructed for LULUCF reporting	653
Table 306:	Allocation of main object-type index numbers and attributes in ATKIS® to IPCC land-use categories	654
Table 307:	Allocation of possible land-use changes to IPCC categories and subcategories	656
Table 308:	Percentage carbon-stock changes in the first year following land-use changes	659
Table 309:	Mean carbon stocks in forest biomass of "forest land converted to other land" areas, for the relevant report years (the value consists of the sum of above-ground and below-ground biomass and dead wood and litter)	660
Table 310:	Factors and dimensioned size data for determining total biomass of plants from harvests	661
Table 311:	Factor classes, and minimum and maximum values, for dimensioned factors (t C ha ⁻¹) for determination of carbon stocks in biomass, 1990 – 2009	662
Table 312:	Allocation of emission factor classes for biomass to the ATKIS object types combined with IPCC land-use categories	663
Table 313:	Schedule for implementation of recommendations from the in-country review in emissions reporting in the areas of LULUCF and KP-LULUCF	671

Table 314:	Completeness - overview of sources and sinks whose emissions are not estimated (NE).....	677
Table 315:	Completeness - overview of sources and sinks that are included elsewhere (IE).....	678
Table 316:	Documentation / record-keeping instruments at the Federal Environment Agency...	697
Table 317:	General checklist for responsible experts	697
Table 318:	Emissions trends in Germany, by greenhouse gas and source category	725
Table 319:	Contributions to emissions trends in Germany, by greenhouse gas and source category	726
Table 320:	Emissions of direct and indirect greenhouse gases and SO ₂ in Germany since 1990.....	727
Table 321:	Changes in emissions of direct and indirect greenhouse gases and SO ₂ in Germany since 1990	727
Table 322:	Changes in emissions of direct and indirect greenhouse gases and SO ₂ in Germany, in each case since the relevant previous year.....	728
Table 323:	Changes in emissions in Germany, by source categories, since 1990 / since the relevant previous year	729
Table 324:	Table 6.1 of the IPCC Good Practice Guidance - Details	731

List of Abbreviations

AbfAbIV	Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (Abfallablagerungsverordnung - AbfAbIV)
ABL	Old German Länder
AD	Activity data
AGEB	Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)
AK	Working group (Arbeitskreis)
ALH	all other deciduous/broadleaf trees with high life expectancies (BWI tree-species group)
ALN	all other deciduous/broadleaf trees with low life expectancies (BWI tree-species group)
ANCAT	Abatement of Nuisances from Civil Air Transport
ARD	Afforestation, reforestation, deforestation
ATKIS	Amtliches Topographisch-Kartographisches Informationssystem (Official topographic-cartographic information system)
AWMS	Animal Waste Management System
BAFA	Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle)
BAT	Best Available Technique
BDZ	Federal Association of the German Cement Industry (Bundesverband der Deutschen Zementindustrie)
BEF	Biomass expansion factors
BEU	Balance of emissions sources for stationary and mobile combustion processes (Bilanz der Emissionsursachen für stationäre und mobile Verbrennungsprozesse)
BGR	Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe)
BGS	Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations
BGW	Bundesverband der deutschen Gas- und Wasserwirtschaft (Federal Association of the German Gas and Water Industry)
BHD	Diameter at breast height (tree-trunk diameter at a height of 1.30 m above the ground)
BHKW	combined heat and power (CHP) unit (Blockheizkraftwerk)
BKG	Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie)
BImSchV	Statutory Ordinance under the Federal Immission Control Act
BML	cf. BMELV
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection
BMVEL	cf. BMELV
BMVG	Federal Ministry of Defence (BMVg)

BMW A	cf. BMW i
BMW i	Federal Ministry of Economics and Technology (BMW i)
BoHE	Main survey on soil use (Bodennutzungshaupterhebung)
BREF	BAT (Best Available Technique) Reference Documents
BSB	Biological oxygen demand (BOD)
BSB ₅	Biological oxygen demand within 5 days (BOD ₅)
BV Kalk	German Lime Association (Bundesverband der Deutschen Kalkindustrie)
BÜK	Soil-overview map (Bodenübersichtskarte)
BWI	Bundeswaldinventur (Federal Forest Inventory)
BZE	Forest soil-condition survey
C ₂ F ₆	Hexafluoroethane
CAPIEL	Coordinating Committee for the Associations of Manufacturers of Industrial Electrical Switchgear and Controlgear in the European Union
CFC	Chlorofluorocarbons (= Fluorchlorkohlenwasserstoffe (FCKW))
CFI	Continuous Forest Inventory
CH ₄	Methane
C _{org}	Organic carbon stored in the soil
CO	Carbon monoxide
CO ₂	Carbon dioxide
CORINAIR	Coordination of Information on the Environment, sub-project: Air
CORINE	Coordinated Information on the Environment
CRF	Common Reporting Format
CSB	Chemical oxygen demand (COD)
D	Germany
D7	Tree-trunk diameter at a height of 7 m above the ground
DEHSt	German Emissions Trading Authority
DESTATIS	<i>Federal Statistical Office</i>
DFIU	Franco-German Institute for Environmental Research, at the University of Karlsruhe
DG	Landfill gas (Deponiegas)
DGMK	German Association of Oil, Natural Gas and Coal Science (Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle eV.)
DIN	Deutsche Industrienorm (DIN standard)
DIW	German Institute for Economic Research (Deutsches Institut für Wirtschaftsforschung)
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
DMKW	Diesel-engine power stations
D _N	Nitrogen in wastewater
DOC	Degradable organic carbon (Degradable organic carbon)
DOC _F	Fraction of DOC dissimilated (converted into landfill gas) Fraction of DOC dissimilated)
DSWF	Datenspeicher Waldfonds ("Forest Fund Database" for the former GDR)
DTKW	Steam-turbine power stations
DVGW	German Association of the Gas and Water Industry (Deutsche Vereinigung des Gas- und Wasserfachs eV.)
EB line	Energy Balance line in the BEC/BEU
EEA	European Environment Agency (European Environment Agency)

EECA	European Electronic Component Manufacturers Association
EEG	Renewable Energy Sources Act (EEG); promulgated in Federal Law Gazette Part I No. 40 of 31 July 2004, p. 1918 ff.)
EF	Emission factor
Oak	Emissions index = Emission factor
E _{KA}	Einwohner mit Kläranlagenanschluss (Inhabitants connected to wastewater-treatment systems)
EL	Fuel oil EL (especially easily liquid)
EM	Emissions
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air pollutants in Europe
EMEV	Emissions-relevant energy consumption (Emissionsrelevanter Energieverbrauch)
ERT	Expert Review Team
ESIA	European Semiconductor Industry Association
ETS	EU Emissions Trading Scheme
EU	European Union
EU-EH	ETS (Europäischer Emissionshandel)
EUROCONTROL	European Organisation for the Safety of Air Navigation
EUROSTAT	Statistical Office of the European Communities
EW	Population
FA	Combustion systems
FAP	Specialised contact person (Fachlicher Ansprechpartner) in the NaSE
FAL	Federal Agricultural Research Institute
FAO	Food and Agriculture Organisation of the United Nations
FCKW	Chlorofluorocarbons (CFCs; Fluorchlorkohlenwasserstoffe)
F gases	Hydrofluorocarbons (HFCs)
FHW	District heating stations
PFC	Perfluorocarbons
FKZ	Research project number (Forschungskennzahl)
FV	Responsible expert (Fachverantwortlicher) in the NaSE
FWL	Thermal output from combustion (Feuerungswärmeleistung)
GAS-EM	GASeous EMISSIONS (a calculation programme for emissions in the agriculture sector)
GEREF	GERman Emission Factor Database
GFA	Large combustion systems (Großfeuerungsanlagen)
GG	Total weight (Gesamtgewicht)
GIS	Gas-insulated switching systems
GMBL	Joint Ministerial Gazette (Gemeinsames Ministerialblatt)
GMES	Global Monitoring for Environment and Security
GMKW	Gas-engine power stations
GPG	Good Practice Guidance
GSE FM-INT	GMES Services Elements Forest Monitoring: Inputs for national greenhouse-gas reporting
GT	Gas turbines
GTKW	Gas-turbine power stations
GuD	Gas and steam turbine power stations,

GWP	Global Warming Potential Global Warming Potential)
HFC	Hydrofluorocarbons (= HFKW)
HFCKW	Hydrochlorofluorocarbons (HCFCs; Wasserstoffhaltige Fluorchlorkohlenwasserstoffe)
HFC	Hydrofluorocarbons Hydrofluorocarbons, HFC)
HQG	Key source: In the NIR, the term "key source" is used synonymously with the term "key category"; i.e. the term includes both emissions sources and sinks.
HS-GIS	High-voltage gas-insulated switching systems
IAI	International Aluminium Institute
IE	Included Elsewhere included elsewhere)
IEA	International Energy Agency
IEF	Implied emission factor
IE	Institute for Energy and Environment (Institut für Energetik und Umwelt)
IFEU	Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung)
IKW	Industrial power stations
IMA	Interministerial Working Group (Interministerielle Arbeitsgruppe)
IPCC	Intergovernmental Panel On Climate Change (Intergovernmental Panel On Climate Change)
IS08	Inventurstudie (Inventory Study) 2008
K	Fuel input for power generation (direct drive)
k.A.	keine Angabe (no entry)
KP	Kyoto Protocol
KS	Sewage sludge
I	Level (= Level assessment pursuant to IPCC Good Practice Guidance)
LF	Landwirtschaftlich genutzten Flächen (agriculturally used land)
LKW	Truck (Lastkraftwagen)
LTO	Landing/take-off cycle
LUCF	Land-Use Change and Forestry Land Use Change and Forestry)
LULUCF	Land-Use Land-Use Change and Forestry Land Use, Land Use Change and Forestry)
MBA	Mechanical-biological waste treatment (Mechanisch-Biologische Abfallbehandlung)
MCF	Methane Conversion Factor Methane Conversion Factor)
MS	Medium voltage
MSW	Amount of municipal waste stored
MVA	Waste incineration plant
MW	Megawatt
N ₂ O	Nitrous oxide (laughing gas)
NA	Not Applicable Not Applicable)
NASA	National Aeronautics and Space Administration
NaSE	National System of Emissions Inventories
NBL	New German Länder
NE	Not Estimated Not Estimated)
NEAT	Non-energy Emission Accounting Tables

NEC	Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain air pollutants National Emission Ceilings).
NEV	Non-energy-related consumption
NFR	New Format on Reporting, Nomenclature for Reporting to the UN ECE New Format on Reporting, Nomenclature for Reporting)
NFZ	Utility vehicles
NH ₃	Ammonia
NIR	National Inventory Report National Inventory Report)
NMVOC	Non-Methane Volatile Organic Compounds Non Methane Volatile Organic Compounds)
NO	Not Occurring Not Occurring)
NO	Nitrogen monoxide
NSCR	Non-selective catalytic reduction
OCF	One-Component Foam One-component foam (installation foam)
OX	Oxidation factor
PAH	Polycyclic aromatic hydrocarbons <i>Polycyclic aromatic hydrocarbons</i>); also <i>PAK</i>
PAK	Polycyclic aromatic hydrocarbons <i>Polycyclic aromatic hydrocarbons</i>); also <i>PAH</i>
PARTEMIS	Measurement and prediction of emissions of aerosols and gaseous precursors from gas turbine engines
PCDD/F	Polychlorinated dibenzo-dioxins/- furans
PF	Process furnaces
PFC	Perfluorocarbons Perfluorocarbons)
PKW	Automobile (Personenkraftwagen)
PU	Polyurethane
QK	Quality control (QC)
QS	Quality assurance
QSE	Quality System for Emissions Inventories
REA	Flue-gas desulphurising plant (Rauchgasentschwefelungsanlage)
ROE	Oil equivalent (OE; Rohöleinheit)
RSt	Raw steel
RWI	Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
S	Fuel input for power generation
S	Heating oil, heavy (high viscosity; "Heizöl S")
S&A report	Synthesis and Assessment Report
SA	Heating oil, heavy (high viscosity; low sulphur content; "Heizöl SA")
SE	Sampling error
SF ₆	Sulphur hexafluoride
SKE	Hard-coal units (Steinkohleneinheiten)
SNAP	Selected Nomenclature for Air Pollution
SO ₂	Sulphur dioxide
STEAG	STEAG Aktiengesellschaft (a large power producer in Germany)
t	Trend (= trend assessment pursuant to IPCC Good Practice Guidance, in the source-category overview tables)

TA Luft	Technical directive on air quality control; First General Administrative Provision on the Federal Immission Control Act(Clean Air Directive)
TAN	Total Ammoniacal Nitrogen
GG	Greenhouse gases (Treibhausgase = GHG)
TM	Dry mass (Trockenmasse)
TOC	Total Organic Carbon Total Organic Carbon)
TREMOD	Traffic Emission Estimation Model Traffic Emission Estimation Model)
TS	Dry matter (Trockenstoff)
TÜV	Technischer Überwachungsverein (Certifying body for technical and product safety)
TVF	Tonne of utilisable production (Tonne verwertbare Förderung)
UBA	Federal Environmental Agency (UBA)
UN ECE	United Nations Economic Commission for Europe United Nations Economic Commission for Europe)
UN FCCC	United Nations Framework Convention on Climate Change United Nations Framework Convention on Climate Change)
UN	United Nations United Nations)
UStatG	Environmental Statistics Act (Umweltstatistikgesetz)
VDEW	Electricity Industry Association (Verband der Elektrizitätswirtschaft)
VDI	Association of German Engineers (Verein Deutscher Ingenieure e.V.)
VDN	Association of German network operators (VDN)
VDZ	German Cement Works Association (Verein Deutscher Zementwerke e.V.)
VGB	Technical association of operators of large power stations (Technische Vereinigung der Großkraftwerksbetreiber e.V.)
VIK	Verband der Industriellen Energie- and Kraftwirtschaft e.V. (VIK) (Association of the Energy and Power Industry), Essen
VOC	Volatile Organic Compounds
VS	Volatile Solids
vTI	Johann Heinrich von Thünen Institute
vTI-AK	Johann Heinrich von Thünen Institute, Institute of Agricultural Climate Research (AK)
vTI-WOI	Johann Heinrich von Thünen Institute, Institute of Forest Ecology and Forest Inventory (WOI)
W	Fuel input for heat generation
WS	Portion of a specific wastewater treatment system (e.g. aerobic, anaerobic)
WZ	Wirtschaftszweig (for purposes of National Classification of Economic Activities (NACE))
XPS	Extruded polystyrene
ZSE	Central System of Emissions (CSE)

Units and sizes

Multiplication factors, abbreviations, prefixes and symbols

Multiplication factor	Abbreviation	Prefix	Symbol
1.000.000.000.000.000	10^{15}	Peta	P
1.000.000.000.000	10^{12}	Tera	T
1.000.000.000	10^9	Giga	G
1.000.000	10^6	Mega	M
1.000	10^3	Kilo	k
100	10^2	Hekto	h
0,1	10^{-1}	Dezi	d
0,01	10^{-2}	Zenti	c
0,001	10^{-3}	Milli	m
0,000.001	10^{-6}	Mikro	μ

Units and abbreviations

Abbreviation	Units
°C	degrees Celsius
a	year
an	animal
cal	calorie
g	gram
h	hour
ha	hectare
J	joule
m ³	cubic metre
pl	(animal) place
ppm	parts per million
t	tonne
W	watt

Standard conversions

Unit	is equivalent to
1 tonne (t)	1 megagram (Mg)
1 kilotonne / thousand tonnes (kt)	1 gigagram (Gg)
1 megatonne / million tonnes (Mt)	1 teragram (Tg)

How to read the introductory information tables

The introductory information tables appear at the beginning of each source category chapter. Each such table provides an overview of the relevant source category's importance and of the methods used in connection with it.

CRF 1.X.1.x (Sample table)					
Key source by level (l) / trend (t) / Tier 2 (Ts)		Gas (key source)	1990 - contribution to total emissions	2009 - contribution to total emissions	Trend
Solid fuels	l / t	CO ₂	13,37 %	23,23 %	+ xx,X
Gaseous fuels	l / t	CO ₂	2,38 %	7,07 %	+xx,X
Liquid fuels	l / t	CO ₂	0,64 %	0,19 %	-xx,X
Solid fuels	l / -	N ₂ O	0,25 %	0,15 %	-xx,X

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 3	+/-50	-	-	-	+/-50				
Distribution of uncertainties	T	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

Key source

The upper section of the table shows the key-source-analysis lines that are relevant for the source category in question, including the category's percentage shares in 1990 and in the last reported year and the pertinent emissions trend. In the NIR, the term "key source (category)" is used synonymously with the term "key category"; i.e. the term includes both emissions sources and sinks.

Gas

The lower section of the table provides information about the emission factors used (EF), the percentage uncertainties for the EF, the uncertainties distribution and the method used to determine the emission factors for the substances in question.

Emission factor (EF)

D = IPCC default
 C = Corinair
 CS = Country-specific
 PS = Plant-specific
 M = Model

Maximum EF uncertainties in %, and distribution of uncertainties

See Chapters 1.7 and 18 for more details

N = Normal
 L = Lognormal
 T = Triangular
 U = Uniform (even distribution)

EF-determination method

D = IPCC default
 RA = Reference approach
 T1 = IPCC Tier 1
 T1a/ T1b/ T1c = IPCC Tier 1a/ 1b/ 1c
 T2 = IPCC Tier 2
 T3 = IPCC Tier 3
 C = CORINAIR
 CS = Country-specific
 M = Model

0 SUMMARY (ES)

As a Party to the United Nations Framework on Climate Change (UNFCCC), since 1994 Germany has been obliged to prepare, publish and regularly update national emission inventories of greenhouse gases. In February 2005, the Kyoto Protocol entered into force. As a result, for the first time ever the international community of nations is required to implement binding action objectives and instruments for global climate protection. This leads to extensive obligations vis-à-vis the preparation, reporting and review of emissions inventories. As a result of Europe's own implementation of the Kyoto Protocol, via the adoption of EU Decision 280/2004¹, these requirements became legally binding for Germany in spring 2004.

Pursuant to Decision 3/CP.5, all Parties listed in ANNEX I of the UNFCCC are required to prepare and submit annual National Inventory Reports (NIRs) containing detailed and complete information on the entire process of preparation of such greenhouse-gas inventories. The purpose of such reports is to ensure the transparency, consistency and comparability of inventories and support the independent review process. The Secretariat of the Framework Convention on Climate Change has made submission of the inventory report a pre-requisite for performance of the agreed inventory reviews.

Pursuant to decision 15/CMP.1, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

Germany now presents its ninth National Inventory Report (NIR 2011), following its inventories for the years 1990 to 2009. This latest report covers the same period (1990 to 2009), and it describes the methods and the data sources on which the calculations are based. The report and the report tables in the Common Reporting Format (CRF) have been prepared in accordance with the UNFCCC guideline on annual inventories (FCCC/SBSTA/2006/9) and, as far as possible, in accordance with the *IPCC Good Practice Guidance* (IPCC-GPG, 2000) and the *IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry* (IPCC-GPG LULUCF, 2003). This year, the NIR contains, for the first time, an additional Part II, along with additional sub-chapters in the existing part, in conformance with expanded requirements under the Kyoto Protocol and the relevant decisions at the European level.

Part I of the NIR presents, in Chapters 1 to 10, all the information relevant to the annual greenhouse-gas inventory.

Chapter 1 provides background information about climate change and about greenhouse-gas inventories, as well as further information relative to the Kyoto Protocol. This section describes the National System pursuant to Article 5.1 of the Kyoto Protocol, which system is designed to aid and assure compliance with all reporting obligations with respect to atmospheric emissions and storage in sinks. In addition, this chapter describes the basic principles and methods with which the emissions and sinks of the IPCC categories are calculated, presents a short summary of key-source assessment and describes the Quality System for Emissions Inventories (QSE). The chapter concludes with sections on uncertainties analysis and completeness analysis.

¹ Decision No. 280/2004/EC of the European Parliament and the Council of 11 February 2004 on a system for monitoring greenhouse-gas emissions in the Community and for implementing the Kyoto Protocol (OJ. EU L 49 p. 1)

Chapter 2 provides a general overview of development of emissions of direct and indirect greenhouse gases and of storage of carbon dioxide in sinks.

Chapters 3 to 9 present information about the individual source and sink groups. Along with general descriptions and information relative to the methods used, the sub-chapters also include information about pertinent uncertainties, quality assurance and quality control, recalculations carried out and planned improvements for relevant source and sink categories.

The inventories, the National System and the Quality System for Emissions Inventories have all been further improved in keeping with the results of the reviews that have taken place in recent years. More-detailed information about recalculations, and information relative to the improvements and changes made with regard to the last greenhouse-gas inventory, is presented in **Chapter 10**.

Part II of the NIR, in **Chapters 11 to 16**, presents the so-called "Kyoto-NIR", in fulfillment of the expanded requirements for Kyoto reporting, and in keeping with the required organisation (annotated NIR).

Chapter 11 contains all information relative to Kyoto reporting in the areas of land use, land-use changes and forestry (LULUCF), especially the definition of "forest" chosen, details on the land-classification technique used and all information relative to selected activities pursuant to Arts. 3.3 and 3.4 of the Kyoto Protocol.

Chapter 12 is devoted completely to accounting for Kyoto units, a process for which, in Germany, the German Emissions Trading Authority (DEHSt) is responsible.

Chapters 13 and 14 provide an overview of changes made in the National System, and at the German Emissions Trading Authority, with the aim of ruling out the possibility of any undue influences on Kyoto reporting.

Chapter 15 lists all the measures that Germany is taking to minimise negative impacts pursuant to Article 3 (14).

Chapter 16 presents any required further information relative to Kyoto reporting.

Annexes 1 through 7, in **Chapters 17-23**, presented more-detailed descriptions of key categories, of individual source categories, of the CO₂-reference procedure, of completeness issues, of the National System and the Quality System, of the CSE emissions database and of uncertainties.

More-detailed information about specific areas is presented in the literature listed in **Chapter 24**.

The Federal Environment Agency makes all calculations for the greenhouse-gas inventory and carries out all relevant compilation. Data on emissions and sinks in the land use, land-use changes and forestry sector have been provided by the Johann Heinrich von Thünen Institute (vTI).

0.1 Background information on greenhouse-gas inventories and climate change (ES.1)

0.1.1 Background information about climate change (ES1.1)

Ever since the start of industrialisation, significant trans-regional and global changes in the substance balance of the atmosphere have been observed as a consequence of human

activities. Worldwide, concentrations of carbon dioxide (CO₂) have risen by approximately 35 % compared to their levels in pre-industrial times, whilst those of methane (CH₄) have increased by 145 % and those of nitrous oxide (N₂O) by 18 %. Furthermore, a number of brand-new substances such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF₆) have entered the atmosphere which almost never occur in nature and are generated almost exclusively by humans. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)² shows that human impacts on climate are scientific fact.

0.1.2 Background information about greenhouse-gas inventories (ES1.2)

In February 2005, the Kyoto Protocol entered into force. As a result, the international community of nations is required to implement binding action objectives and instruments for global climate protection. In the framework of the Kyoto Protocol, the European Union (with 15 Member States at that time) has committed to reducing its greenhouse-gas emissions by 8% by the 2008–2012 period, in comparison to their base-year levels (1990 and 1995³). This commitment has been divided within the EU in the framework of a burden-sharing agreement between the participating Member States⁴. Under this agreement, Germany has agreed to reduce its emissions by 21 % in comparison to the base year and thus has agreed to make a substantial contribution to fulfillment of the EU's commitment. Consequently, Germany's relevant measures, and its calculations relative to emissions reductions, are being followed with considerable interest.

0.1.3 Background information relative to supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol (ES.1.3)

The present report, in keeping with decision 15/CMP.1, presents, for the first time, supplementary information pursuant to Article 7 (1) of the Kyoto Protocol, for support of the review process under the Kyoto Protocol. This information includes:

- General information on inventory preparation in connection with reporting pursuant to Article 3 (3) Kyoto Protocol and for the selected additional activities pursuant to Article 3 (4) Kyoto Protocol; (cf. Chapter 11)
- Information regarding the certificates under the Kyoto Protocol in connection with decisions 13/CMP.1 and 5/CMP.1; (cf. Chapter 12)
- Information regarding changes in the National System of emissions reporting pursuant to Article 5 (1) of the Kyoto Protocol; (cf. Chapter 13)
- Information regarding changes in the National Registry; (cf. Chapter 14)
- Information regarding minimisation of negative impacts pursuant to Article 3 (14) of the Kyoto Protocol; (cf. Chapter 15)

² IPCC Fourth Assessment Report: Climate Change 2007, available in the Internet at: <http://www.ipcc.ch/ipccreports/assessments-reports.htm>

³ For HFC, PFC and SF₆

⁴ Burden-sharing agreement, adopted with Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder [OJ L 130 of 15 May 2002]

0.2 Combined greenhouse-gas emissions, their storage in sinks, and emissions and storage from KP-LULUCF activities (ES.2)

0.2.1 Greenhouse-gas inventory (ES.2.1)

As of 2009, Germany had fulfilled its obligations within the framework of the aforementioned European burden-sharing, amounting to a reduction of 25.3 % with regard to the base-year emissions reported in 2006⁵, 1,232,429.543 Gg (CO₂ equivalent). As a result of the global economic crisis, overall emissions were considerably lower in 2009 than they had been in earlier years. With respect to 2008, emissions decreased by a full 6.3 % (cf. Chapter 2.1).

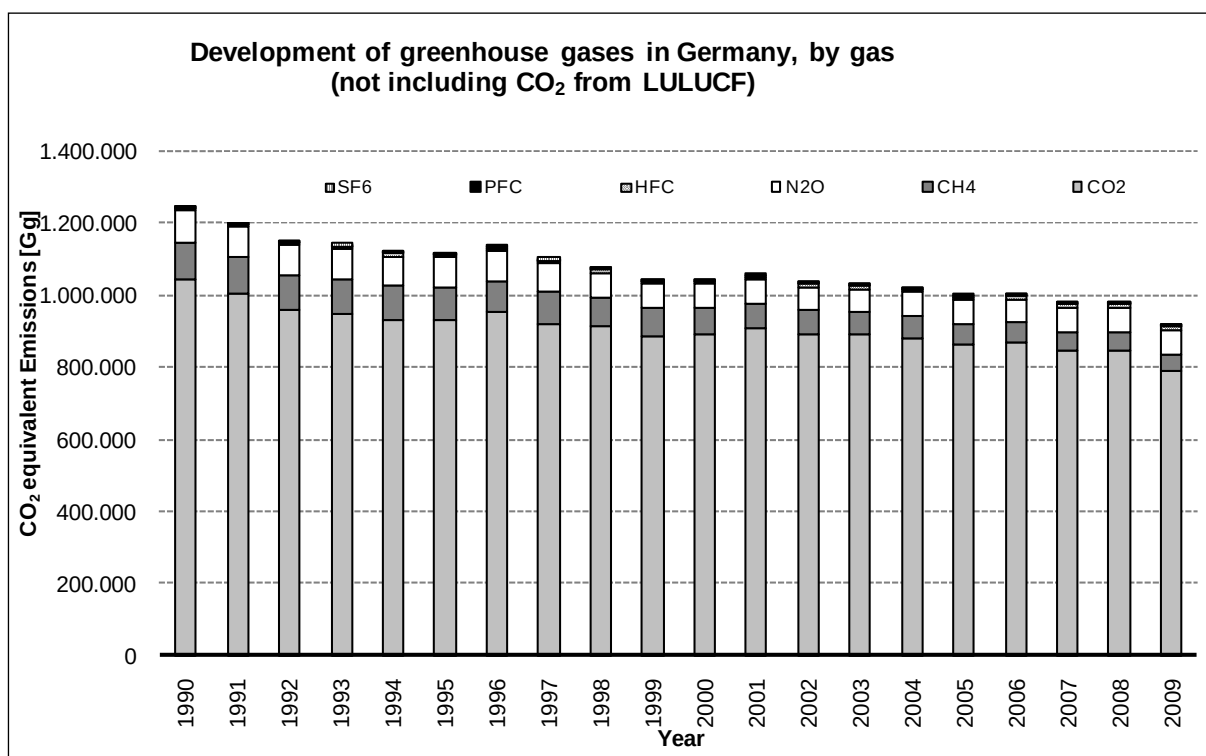


Figure 1: Development of greenhouse gases in Germany since 1990, by greenhouse gases⁶.

The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). This is hardly surprising given that, in any given year the various greenhouse gases account for varying proportions of total emissions (cf. Table 2). Detailed tables are provided in Annex Chapter 22.3.

In 2009, carbon-dioxide releases were the most significant greenhouse-gas emissions, accounting for 85.7 % of all such emissions. Most of the carbon dioxide is released via stationary and mobile combustion of fossil fuels. As a result of a disproportionately large reduction of other greenhouse-gas emissions, CO₂ emissions' share of total emissions has increased by 2.5 percentage points since the base year. Methane (CH₄) emissions from animal husbandry, fuel distribution and landfills account for 5.3 %. Emissions of nitrous oxide (N₂O), caused primarily by agriculture, industrial processes and burning of fossil fuels, contribute 7.3 % of greenhouse-gas releases. Fluorocarbons (so-called "F gases") account

⁵ The reference figures for determining achievement of reduction obligations under the Kyoto Protocol have been defined in keeping with results of review of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol. Such definition does not take account of any further possible improvements in the basic data. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %.

⁶ CO₂ emissions and storage in soils are reported under land-use changes and forestry.

for about 1.7 % of total emissions. The distribution of greenhouse-gas emissions in Germany is typical for a highly developed and industrialised country.

Table 1: Emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks, in CO₂ equivalents (Gg)	1990	1995	2000	2005	2006	2007	2008	2009
Net CO ₂ emissions / storage	1,009,739	897,803	857,842	878,950	883,594	861,491	862,410	805,959
CO ₂ emissions (not including LULUCF)	1,041,688	930,420	890,994	863,955	870,164	847,276	847,967	788,803
CH ₄	107,293	92,198	74,759	57,225	54,172	52,048	51,262	48,799
N ₂ O	87,833	82,617	64,995	64,926	63,804	66,311	67,364	66,897
HFC	4,369	6,469	6,483	10,001	10,539	11,145	11,474	11,952
PFC	2,708	1,750	781	709	571	530	531	432
SF ₆	4,785	7,220	4,826	3,726	3,651	3,537	3,288	3,223

Total emissions / storage, including LULUCF	1,216,727	1,088,056	1,009,687	1,015,537	1,016,332	995,061	996,328	937,262
Total emissions, not including CO₂ from LULUCF	1,248,676	1,120,673	1,042,839	1,000,541	1,002,901	980,847	981,885	920,106

GG emissions / sinks, by source and sink categories, in CO₂ equivalents (Gg)	1990	1995	2000	2005	2006	2007	2008	2009
1, Energy	1,019,041	903,117	857,747	826,035	830,703	807,504	809,591	760,126
2, Industrial processes	94,532	97,013	77,143	80,685	81,938	84,623	82,017	73,324
3, Solvent and other product use	4,477	3,553	2,909	2,052	2,074	1,949	1,812	1,786
4, Agriculture	86,740	76,403	77,191	73,402	71,778	71,466	74,508	72,702
5, Land use, land-use changes & forestry	-31,175	-31,849	-32,384	15,761	14,074	15,188	15,216	17,563
CO ₂	-31,949	-32,617	-33,152	14,995	13,430	14,214	14,443	17,155
N ₂ O & CH ₄	774	768	768	765	644	974	773	408
6, Waste	43,111	39,820	27,081	17,602	15,764	14,331	13,182	11,760

Table 2: Contributions to emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks; shares for various GHG, not including CO ₂ from LULUCF (%)	1990	1995	2000	2005	2006	2007	2008	2009
CO ₂ emissions (not including LULUCF)	83,4	83,0	85,4	86,3	86,8	86,4	86,4	85,7
CH ₄	8,6	8,2	7,2	5,7	5,4	5,3	5,2	5,3
N ₂ O	7,0	7,4	6,2	6,5	6,4	6,8	6,9	7,3
HFC	0,3	0,6	0,6	1,0	1,1	1,1	1,2	1,3
PFC	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,0
SF ₆	0,4	0,6	0,5	0,4	0,4	0,4	0,3	0,4
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

GG emissions / sinks; shares for emission & sink categories, not including CO ₂ from LULUCF (%)	1990	1995	2000	2005	2006	2007	2008	2009
1. Energy	81,6	80,6	82,3	82,6	82,8	82,3	82,5	82,6
2. Industrial processes	7,6	8,7	7,4	8,1	8,2	8,6	8,4	8,0
3. Solvent and other product use	0,4	0,3	0,3	0,2	0,2	0,2	0,2	0,2
4. Agriculture	6,9	6,8	7,4	7,3	7,2	7,3	7,6	7,9
5. Land use, land-use changes & forestry (N ₂ O)	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,0
6. Waste	3,5	3,6	2,6	1,8	1,6	1,5	1,3	1,3
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

0.2.2 KP-LULUCF activities (ES.2.2)

Storage of CO₂ pursuant to Article 3.3 has increased by 9.3 % with respect to 2008. The increase has occurred because 6.76 % more CO₂ has been stored via afforestation and reafforestation and 1.3 % less has been emitted via deforestation. N₂O emissions have remained constant.

CO₂ storage pursuant to Article 3.4, via Forest Management activity, has remained nearly constant throughout the report period. CH₄ emissions have increased by about 41 %, while N₂O emissions have remained constant.

0.3 Combined emissions estimates, and trends for source and sink groups, including KP-LULUCF activities (ES.3)

0.3.1 Greenhouse-gas inventory (ES.3.1)

Figure 2 shows the contributions of individual source and sink categories to total greenhouse-gas emissions. It highlights the relative constancy of the shares of the various source and sink categories and the absolute predominance of energy-related emissions. On the other hand, energy-related emissions have continuously decreased over time. The fluctuations that are superimposed over this trend are largely temperature-related. Because winter temperatures affect heating patterns, they also affect energy consumption for heating, and thus they have major impacts on annual trends in energy-related CO₂ emissions.

Overall, greenhouse-gas emissions have decreased considerably with respect to the base year (decrease of CO₂-equivalent emissions by 25.3 %). Considerations of the various components involved confirm this trend, to varying degrees. The emissions changes, with

respect to the base-year emissions reported in the 2006 report⁷, amounting to 1,232,429.543 Gg CO₂ equivalent, are as follows for the most important greenhouse gases in terms of quantity: - 24.3 % for carbon dioxide (CO₂); - 54.5 % for methane (CH₄); and - 23.8 % for nitrous oxide / laughing gas (N₂O). The corresponding trends for the so-called "F" gases, which contribute about 1.7 % of greenhouse-gas emissions overall, have not been as clearly similar to each other, however. In keeping with the introduction of new technologies, and with use of these substances as substitutes, since base year 1995 SF₆ emissions decreased by 55.4 % and PFC emissions dropped by 75.3 %, while HFC emissions increased by 84.8 %.

In comparison to the previous year, 2008, total emissions decreased enormously, by a full 6.3 %. As to the reasons for the decrease, the impacts of the global economic crisis outweighed all other factors. Emissions can be expected to increase again in 2010, as a result of the economic recovery that has occurred.

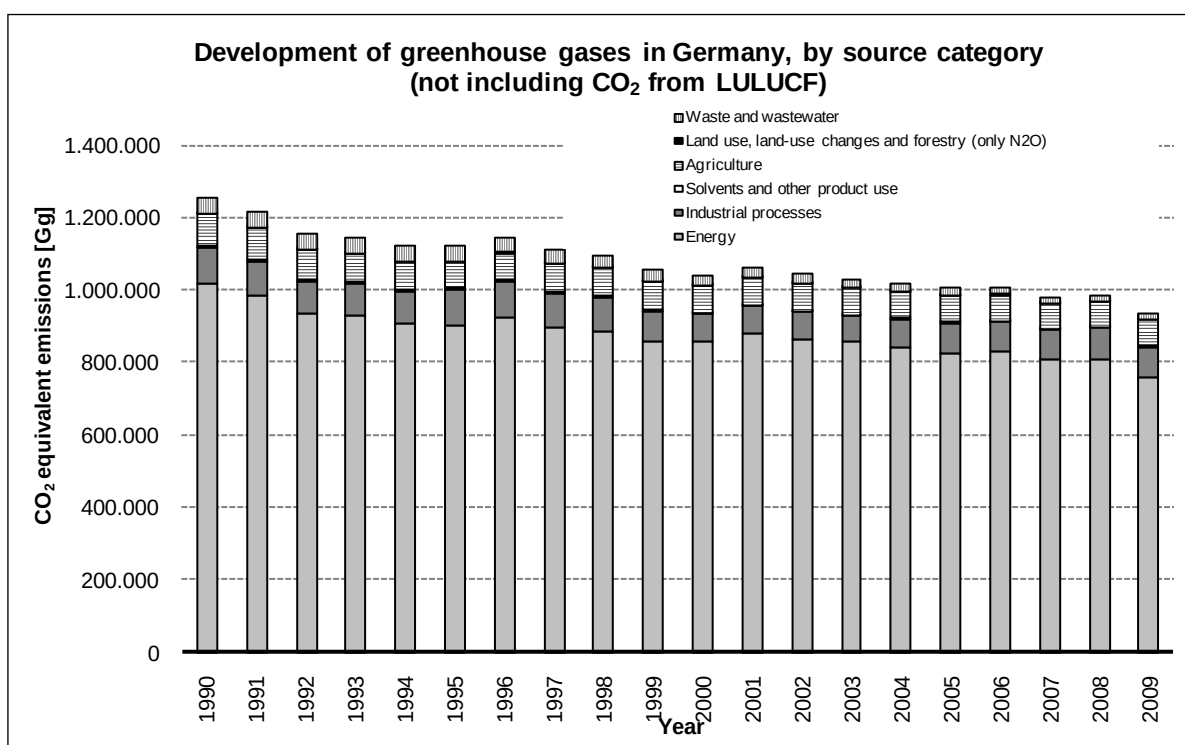


Figure 2: Emissions trends in Germany since 1990, by source categories⁸.

Figure 3 shows the relative developments of emissions from polluter categories since 1990. The most significant reduction occurred in the area of waste emissions. Increased recycling of recyclable materials (Packaging Ordinance), and reuse of materials as compost (Biowaste Ordinance), have led to a reduction in the quantity of waste that is landfilled and hence to a reduction in landfill emissions. In the area of emissions from industrial processes, the emission-reducing effects of measures in the field of adipic acid production in 1997 were substantial. Emissions from solvent and other product use decreased markedly, as a result of decreased narcotic use of N₂O. The development of emissions from agriculture essentially

⁷ The reference figures for determining achievement of reduction obligations under the Kyoto Protocol have been defined in keeping with results of review of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol. Such definition does not take account of any further possible improvements in the basic data. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %.

⁸ CO₂ emissions and storage in soils are reported under land-use changes and forestry.

follows the development of livestock data. A detailed discussion of emissions trends is presented in Chapter 2, Trends in Greenhouse Gas Emissions.

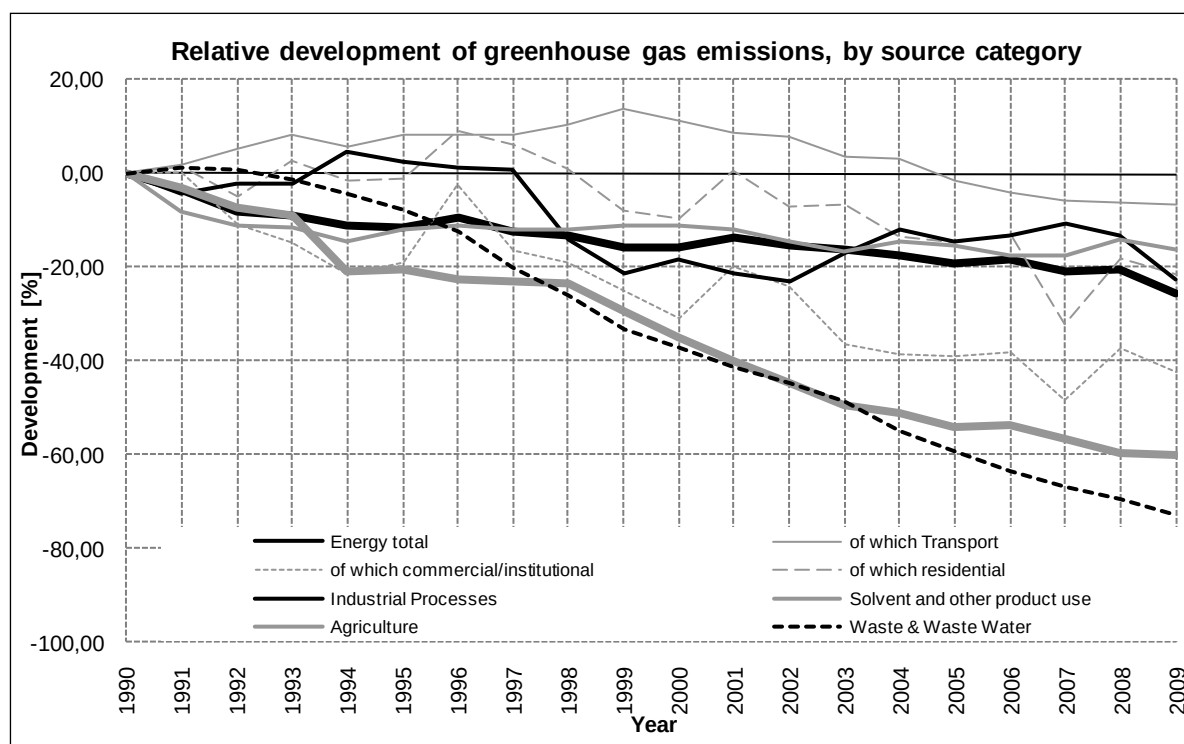


Figure 3: Relative development of greenhouse-gas emissions since 1990, by source categories⁹

0.3.2 KP-LULUCF activities (ES.3.2)

Germany reports under KP-LULUCF Article 3 (3), and it reports in the area of forest management with regard to the selected additional activities pursuant to Article 3 (4) Kyoto Protocol. It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

Under Article 3.3, it reports storage of 3,713.55 Gg CO₂ equivalent. The emissions are composed of storage of CO₂ via afforestation and reafforestation, amounting to 4,779.19 Gg CO₂ equivalent, and emissions from deforestation, amounting to 1,065.64 Gg CO₂ equivalent. Under Article 3.3, it reports CO₂ storage of -3,717.39 Gg CO₂ equivalent and N₂O emissions of 3.85 Gg CO₂ equivalent.

Under Article 3.4, it reports storage of 20.526,72 Gg CO₂ equivalent. The relevant storage consists of CO₂ storage of 21.240,13 Gg CO₂ equivalent and emissions of 713,41 Gg CO₂ equivalent. Under Artikel 3.4, it reports CO₂ storage of 20.576,98 Gg CO₂ equivalent, N₂O emissions of 45,65 Gg CO₂ equivalent and CH₄ emissions of 4.62 Gg CO₂ equivalent.

On afforestation areas, a storage increase of 302.79 Gg CO₂ equivalent was determined for the period from 2008 to 2009. That positive trend is also seen in the area of deforestation, in which emissions decreased slightly, by 14.17 Gg CO₂ equivalent. On the other hand, storage in connection with forest management decreased slightly from 2008 to 2009. The pertinent decrease amounted to 29,22 Gg CO₂ equivalent (cf. also Table 13 in Chapter 2.5).

⁹ CO₂ emissions and storage in soils are reported under land-use changes and forestry.

1 INTRODUCTION

1.1 Background information regarding greenhouse-gas inventories and climate change, and supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

1.1.1 Background information about climate change

Climate change consists of changes in average weather conditions, and in extreme events, over an extended period of time; it can occur in a particular area or be global.

Climate change may be attributable to the following causes:

- Changes in so-called "geo-astrophysical parameters" such as the solar constant, elements of the earth's orbit, etc.
- Changes in the earth's surface
- Changes in the energy balance in the "earth's surface and atmosphere" system
- Changes in the substance balance in the atmosphere (such as changes in the concentration of greenhouse gases).

Greenhouse gases, among which are carbon dioxide, nitrous oxide (laughing gas), methane, ozone and water vapour (the most important natural greenhouse gas), have a particular property. They allow the energy-rich radiation falling onto the earth from the sun (primarily in the visible, short-wave range) to pass almost unhindered, yet partially absorb the long-wave radiation emitted by the heated earth. This places them in an energetically excited state for a brief time, after which they return to their original basic state whilst emitting infrared radiation. Heat radiation occurs equally in all spatial directions – in other words, a substantial portion of this is returned to the earth's surface ("*thermal back radiation*"). So that this additional quantity of energy may nevertheless be irradiated (this must occur due to the dynamic, energetic equilibrium, at whose centre are the earth and the atmosphere), the earth must have a correspondingly higher temperature. This is a simplified description of the greenhouse effect.

Without the greenhouse gases occurring naturally, life on our planet would not be possible. Instead of having an average global temperature of approximately 15°C, the earth would have an average temperature of approximately –18°C. In other words, the natural greenhouse effect protects our life on earth.

Since the beginning of the industrial era, mankind has brought about marked changes in the atmosphere's substance cycles. These changes have been caused by humans' energy-intensive lifestyles and related emissions of greenhouse gases. Since 1750, the worldwide concentration of carbon dioxide (CO₂) has increased by about 35 %, while that of methane (CH₄) has more than doubled and that of nitrous oxide (N₂O) has increased by about 18 %. Furthermore, a number of brand-new substances such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF₆) have entered the atmosphere which almost never occur in nature and are generated almost exclusively by humans. In spite of being "trace gases", greenhouse gases have considerable impacts. Their increasing concentrations have led to the anthropogenic (human-caused) greenhouse effect, which supplements the natural greenhouse effect.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2007) is very clear on the following point: Observations and measurements unambiguously

indicate that the climate system is warming, with respect to its pre-industrial state, and that humans are primarily responsible for this trend. The global warming is clearly apparent in the increase of the *average* global near-ground air temperature, amounting to 0.76°C in the period 2001 to 2005 with respect to pre-industrial levels (1859 to 1899); in the increase of the average temperature of the world's oceans (for layer 0 to 700 m, by 0.10°C for the period 1961 to 2003); in extensive melting of ice and snow; and in the increase of average global sea level. Pursuant to the IPCC (2007), these trends have intensified, and the rate of warming seen over the past 50 years (1996 to 2005) is twice as high as that of the past 100 years (IPCC 2007: S. 237, WG I). The climate change will have extensive impacts on ecological and societal systems, with potentially serious consequences.

If dangerous impacts of climate change are to be prevented, global warming must be constrained to no more than 2 °C in comparison to pre-industrial levels. Of that increase, 0.7°C have already taken place. In addition, so the IPCC (2007), greenhouse-gas emissions have to peak, and a trend reversal has to take place, within the next 10 years. Furthermore, so the IPCC (2007), by 2050 global emissions have to be reduced by at least 50 %, with respect to 2000, if the temperature increase is to be limited to 2 and 2.4 °C.

1.1.2 Background information about greenhouse-gas inventories

The world's nations were quick to recognize that the expected temperature changes would pose threats to ecosystems and to human civilisation, because the changes would take place relatively quickly, and existing systems would not be able to adapt to the new climate conditions without suffering damage.

The Framework Convention on Climate Change was adopted in 1992, in Rio de Janeiro, by nearly all nations of the world. Since 1994, the countries listed in Annex I of the Framework Convention on Climate are required to submit annual inventories of greenhouse gases, as of 15 April of each year, to the Secretariat of the Framework Convention. Such inventories must include data on emissions and sinks for the base year (1990 for CO₂, N₂O, CH₄; 1995 for HFCs, PFCs, SF₆) and for all years until two years prior to the year of the relevant report.

At the third Conference of the Parties, held in Kyoto, legally binding obligations on emissions limitations and reductions were defined, for the first time, for industrialised countries. Pursuant to the Kyoto Protocol, industrialised nations must reduce their emissions of the six greenhouse gases carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆) by an average of 5.2 percent by 2012. In the framework of the Kyoto Protocol, the European Union (then with 15 Member States) has committed to reducing its greenhouse-gas emissions by 8% by the 2008–2012 period, in comparison to their base-year levels. This commitment has been divided up between the participating Member States via a burden-sharing arrangement¹⁰ whereby Germany is called on to make a substantial contribution of a 21 % emissions reduction in comparison to the base year. Consequently, Germany's relevant measures, and its calculations relative to emissions reductions, are being followed with considerable interest.

The effectiveness and success of the Kyoto Protocol vis-à-vis reduction of global greenhouse gas emissions will depend on two key factors: Whether its Parties abide by the rules of the Protocol and meet their obligations, and whether the emissions data used for controlling

¹⁰ Burden-sharing agreement; adopted via Council decision 2002/358/EC

compliance are reliable. As such, national reporting and the subsequent international review of emissions inventories play a key role.

1.1.3 Background information relative to supplementary information, as required pursuant to Article 7 (1) of the Kyoto Protocol (KP NIR 1.1.3.)

Pursuant to to decision 15/CMP.1 of the 1st COP of the Kyoto Protocol, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

In 2008 (with the NIR 2008), Germany began early, on a voluntary basis, to fulfill these reporting obligations. In the process, over the past two years it has begun preparing intensively for the binding reporting required pursuant to Art. 7 of the Kyoto Protocol.

The first binding report, that for 2010 (NIR 2010), was reviewed in detail in September 2010 in the framework of an In-Country Review. That review led to recalculations for some source categories of the 2010 report, as well as a resubmission of the data in November 2010.

In submitting its ninth National Inventory Report (NIR 2011), Germany also submits its fourth inventory report, pursuant to the Kyoto Protocol, that includes all of the information called for in Art. 7. All trend descriptions in the present inventory report are based on the data of the Resubmission 2010.

Information relative to Arts. 3.3 and 3.4 of the Kyoto Protocol (KP-LULUCF) are provided in Chapter 11. Information on bookkeeping relative to Kyoto units is presented in Chapter 12. The relevant changes in the National System are described in Chapter 13, and the changes in the National Registers are described in Chapter 14. Information on minimisation of negative influences pursuant to Art. 3 (14) of the Kyoto Protocol is presented in Chapter 15.

1.2 Description of institutionalisation of inventory preparation, including the legal and procedural definitions relative to the planning, preparation and management of the inventory

Article 5.1 of the *Kyoto Protocol* mandates the establishment of National Systems for preparation of greenhouse-gas emissions inventories. The National System for Germany fulfils the requirements of the *Guidelines for National Systems* (UNFCCC Decision 19/CMP.1), requirements which are binding under the *Kyoto Protocol* and *Decision 280/2004/EC*.

The National System provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through use of the methodological regulations from the *IPCC Guidelines* and the *IPCC Good Practice Guidance*, through ongoing quality management and through continuous inventory improvement.

The National System in Germany was established via an agreement of state secretaries representing the ministries involved in emissions reporting, an agreement set forth in the paper, on basic emissions-reporting principles, entitled "National System" and dating from 5 June 2007.

In recent years, decisive progress has been made in institutionalising the National System. Initially, such progress came via the establishment of the national co-ordinating committee (Single National Entity), issuance of an in-house directive for the Federal Environment Agency and development of a procedure for using monitoring data from European emissions trading. Further institutionalisation is now taking place primarily via signing of relevant agreements with other federal institutions, with industrial associations and with individual business enterprises.

1.2.1 Overview of the institutional, legal and procedural definitions relative to preparation of greenhouse-gas inventories and of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

In Germany, the National System has been established at the ministerial level, under the leadership of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The System now incorporates other German ministries, including the Federal Ministry of the Interior (BMI), the Federal Ministry of Defence (BMVg); the Federal Ministry of Finance (BMF), the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of Transport, Building and Urban Development (BMVBS) and the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV). As a result, the process of emissions-inventory preparation now includes all of the key institutions that are in a position to make high-quality specialised contributions to it.

In an agreement reached by the state secretaries of the aforementioned federal ministries, and set forth in the "Nationales System" ("National System") principles paper on emissions reporting of 5 June 2007, the relevant responsibilities of the various ministries were defined. In addition, it was resolved that the Federal Environment Agency (UBA) should serve as the Single National Entity (national co-ordinating agency) for Germany (cf. Chapter 1.2.1.2). In support of the reporting process, the participating ministries established a co-ordinating committee (cf. Chapter 1.2.1.1). For co-ordination of pertinent work within the Federal Environment Agency, a working group on emissions inventories was established (cf. Chapter 1.2.1.3). For implementation of the IPCC Good Practice Guidance relative to quality control and assurance, a Quality System of Emissions was established within the Federal Environment Agency in 2005, via an in-house directive (cf. Chapter 1.2.1.5).

The following Figure 4 provides an overview of the structure of the National System in Germany.

The paper "National System" of 5 June 2007, on basic principles of emissions reporting, is provided in Annex Chapter 22.1.1.

The National System on Agriculture and LULUCF, within the portfolio of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), is described in Chapter 1.2.1.5.

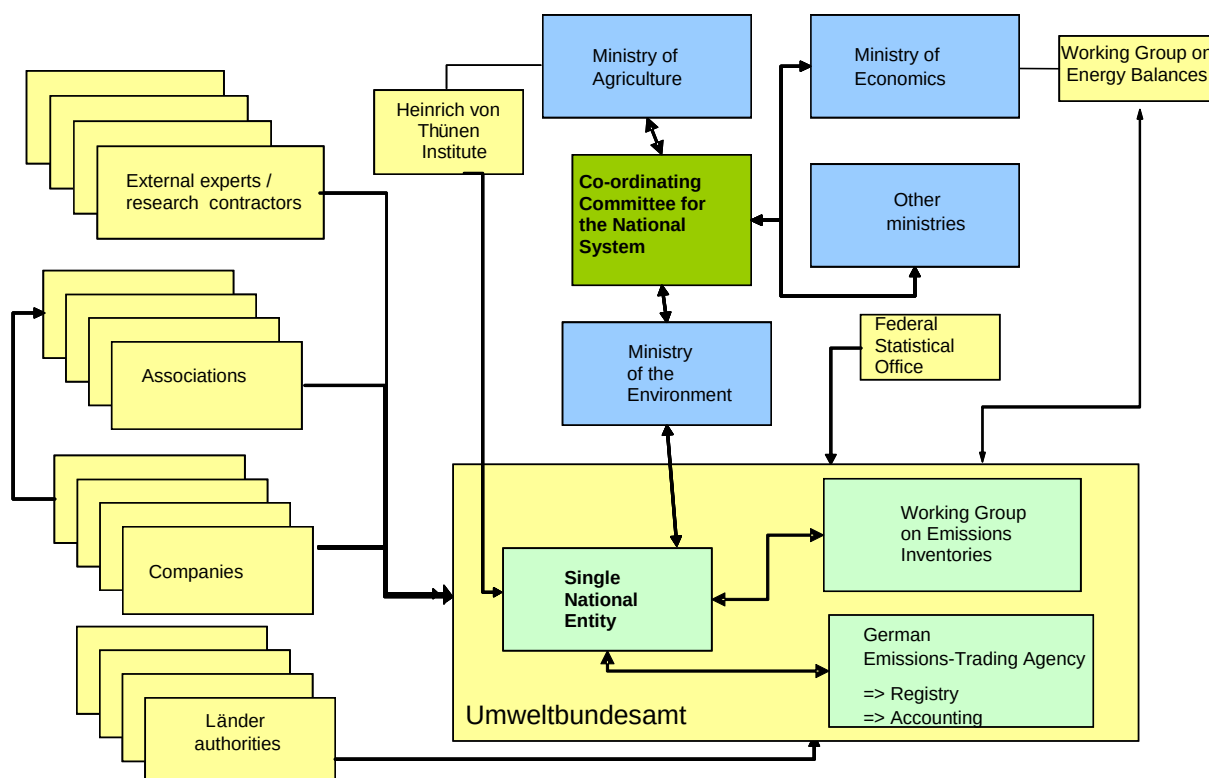


Figure 4: Structure of the National System of Emissions (NaSE)

1.2.1.1 The National Co-ordinating Committee

In its Sec. 2, the state secretaries' resolution of 5 June 2007 provides for the establishment of a National Co-ordinating Committee that is to be headed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and to include representatives of all federal ministries that participate in emissions reporting.

The National Co-ordinating Committee has the tasks of supporting the emissions-reporting process and clarifying open issues pertaining to the National System. In particular, the committee defines key-source and key-sink categories and resolves any pertinent uncertainties.

In addition, the National Co-ordinating Committee is responsible for approving inventories and the reports required pursuant to Arts. 5, 7 and 8 of the Kyoto Protocol.

The National Co-ordinating Committee met for the first time on 21 December 2007. It meets at least once per year, at the invitation of the BMU. Between meetings, the participating federal ministries carry out co-ordination via electronic communication.

The National Co-ordinating Committee has become a basic component of the National System. This body's establishment has implemented the recommendation in the Initial Review 2007: Institutional, legal and procedural arrangements (Document FCCC/IRR/2007/DEU of 12 December 2007, Para 11), and it has contributed to the institutionalisation of the National System of Emissions Reporting.

1.2.1.2 Co-ordination agency (SNE) for the National System

The state secretaries' policy paper appointed the Federal Environment Agency to carry out **tasks of the national co-ordination agency for emissions reporting** (Single National

Entity). The Federal Environment Agency's in-house directive (Hausanordnung) 11/2005 gave section "Emissions Situation" (FG I 2.6) responsibility for carrying out that function.

The Single National Entity's tasks include planning, preparing and archiving of inventories, describing inventories in the inventory reports and carrying out quality control and assurance for all important process steps. The *Single National Entity* serves as a central point of contact, and it co-ordinates and informs all participants in the *National System*. During the period 2003 to 2007, the Single National Entity has given priority to developing new data sources. Since 2008, its focus has been especially on improving existing data sources, and safeguarding their availability for the long term, by improving the **institutionalisation of the National System**. Furthermore, institutions that need to be integrated within the *National System* have been identified and are now being successively integrated (cf. Chapter 1.2.1.4). Other important work has had to do with implementing the Quality System for Emissions Inventories (cf. Chapter 1.2.2).

The Single National Entity has developed two key **instruments** for carrying out those tasks:

The Federal Environment Agency's *Central System of Emissions* (CSE) database is the national, central database for emissions calculation and reporting. It is used for central storage of all information required for emissions calculation (methods, activity rates, emission factors). The CSE is the main instrument for documentation and quality assurance at the data level.

Both within and outside of the Federal Environment Agency, the Quality System for Emissions Inventories (QSE) provides the necessary framework for good inventory practice and for routine quality assurance. Established within the Federal Environment Agency in 2005 via in-house directive 11/2005, it comprises the processes necessary for continually improving the quality of greenhouse-gas-emissions inventories. The framework it provides includes defined responsibilities and quality objectives relative to methods selection, data collection, calculation of emissions and relevant uncertainties and recording of completed quality checks and their results (confirmation that objectives were reached, or, where objectives were not reached, listing of the measures planned for future improvement). Ongoing quality improvement in the framework of the QSE is supported by a database that serves as the repository for all tabular documents emerging from the national QC/QA process (QC/QA plan, checklists, lists of responsibilities, etc.).

The quality control procedures have been developed with the help of external experts, taking special account of the Federal Environment Agency's work structures, general guidelines for quality assurance and the *IPCC Good Practice Guidance*.

Since 2008, the QSE has been expanded to cover the entire National System. This has occurred via integration of additional authorities, institutions and inventory experts in the quality-management process – via specification of minimum requirements for data documentation, QC/QA and archiving. In addition, the procedure is designed to enable other organisations to build their own internal quality assurance systems on the basis of their existing structures. It thus addresses the comments provided in Paragraph 18 of the 2007 Initial Review. The QSE is described in detail in Chapter 1.2.2.

The manner in which these instruments interact in the framework of inventory preparation is shown in Figure 5.

National System (NaSE)

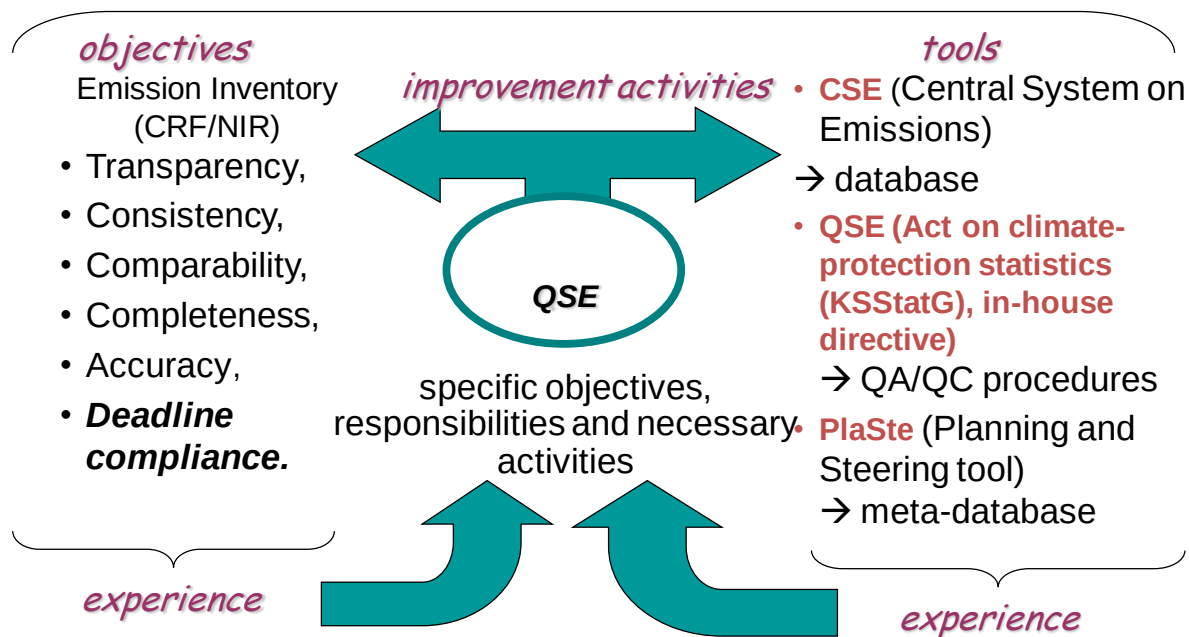


Figure 5: NaSE – Objectives and instruments

1.2.1.3 Working Group on Emissions Inventories, in the Federal Environment Agency

In its inventory work, and especially in work relative to emission factors, the Single National Entity receives significant support from other working units of the Federal Environment Agency. In addition, associations, companies and other independent organisations are integrated within the National System primarily via the Federal Environment Agency's specialised units that are responsible for the specific issues involved in each case.

In 2003, a *Working Group on Emissions Inventories* was set up to co-ordinate relevant work within the Federal Environment Agency; it liaises with all of the agency's employees who are involved in inventory preparation.

The Single National Entity convenes meetings of the working group twice a year. In addition, relevant members of the working group are expected to meet as necessary to discuss specific issues and to make the necessary in-house arrangements. The working group has met 14 times since it was established.

Necessary information is provided via the working group's events and through an intranet area devoted to emissions reporting.

To inform all of the Federal Environment Agency staff who participate in inventory preparation about any changes in the Central System on Emissions, the Single National Entity also issues a monthly e-mail newsletter regarding the CSE database.

1.2.1.4 Co-operation between the Single National Entity and a) other federal institutions and b) non-governmental organisations

In the "National System" policy paper of 5 June 2007 on emissions reporting (which is presented in Chapter 22.1.1), the involved ministries have defined responsibilities relative to the various relevant source and sink categories.

Furthermore, the relevant resolution sets forth that involved federal ministries are to undertake suitable activities to close data gaps that fall within their areas of responsibility. As necessary, data gaps are to be closed via provision of pertinent data, or via relevant calculations. In some cases, required data may be provided by reliable third parties.

For some of the data streams moving to the Single National Entity from other federal institutions, special agreements have to be concluded between a) the relevant institution in the case in question and b) the Single National Entity.

With regard to **data provision by the Federal Statistical Office**, relative to emissions reporting, a legal arrangement was made in 2009, in the framework of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), that, in particular, enables provision of data subject to statistical secrecy. On that basis, on 13 January 2010 an administrative agreement between the Federal Environment Agency and the *Federal Statistical Office* came into force that specifies data deliveries for emissions-reporting purposes. In anticipation of the agreement, data was already provided in 2009 on the basis of the agreement, however. The agreement provides for annual reviews of the Federal Environment Agency's data requirements. The list of provided data was revised for the first time in June 2010.

Furthermore, the "National System" policy paper of 5 June 2007 on basic principles for emissions reporting assigns responsibility for the area of agriculture and LULUCF to the BMELV. This includes reporting on agriculture and on LULUCF, for purposes of the UN Framework Convention on Climate Change and the Kyoto Protocol (including reporting pursuant to Art. 3.3 KP). In addition, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is responsible for reporting crediting, as opted for by state-secretary resolution of 22 December 2006, of forestry activities pursuant to Art. 3 (4) of the KP. That responsibility includes pertinent required data collection, emissions calculation and provision for reporting (in CRF tables), and for the relevant NIR chapters.

Via a directive of 29 August 2007, the Federal Agricultural Research Institute (FAL) has been commissioned to carry out this task within the portfolio of the BMELV. Following a restructuring of the BMELV's departmental research, and with effect as of 1 January 2008, responsibility for this task has been transferred to the **Johann Heinrich Von Thünen Institute (vTI)**.

On 13 February 2008, the vTI concluded an agreement with the Federal Statistical Office on provision of emissions data on the basis of agricultural statistics. In addition, a research and development agreement between the vTI and the *Association for Technology and Structures in Agriculture (KTBL)* has been in place since 7 July 2009. That agreement specifies the necessary supporting work for emissions reporting.

At the National Co-ordinating Committee's third meeting, held on 1 July 2009, the BMELV presented a revised draft of a concept for the National System in the area of agriculture and forestry, including a quality concept for KP-LULUCF (Arts. 3.3. and 3.4 KP). Following the meeting, the concept was refined, via exchanges between the Single National Entity and the vTI. It has been in place since August 2009. The concept is being extensively revised, for the 2012 report, on the basis of a request made by the ERT in the framework of the In-Country Review 2010. The relevant revision will take account of the ERT's recommendations.

Furthermore, a working group on emissions reporting has been established within the vTI, to serve as liaison to the National System. That working group also has responsibility for planning and QC/QA. The establishment of the new body addresses the reference provided

in Paragraph 16 of the 2007 Initial Review. In addition, an action plan has been prepared that addressed the reporting problems identified by the ERT in the 2010 Review and describes how the problems are to be eliminated. The action plan is included in Chapter 19.5.2.7.

Responsibility for co-ordination of the Working Group on Emissions Reporting lies with the vTI's Institute of Agricultural Climate Research (AK). Responsibility for reporting on agriculture and LULUC lies with the same institute, while responsibility for reporting on forests pursuant to the Convention and Kyoto Protocol Arts. 3.3 and 3.4 lies with the vTI's Institute of Forest Ecology and Forest Inventory (WOI).

The working group on emissions reporting at the vTI is integrated within the National System via direct (inter-departmental) participation within the Single National Entity's communications structures. The working group at the vTI is also part of the working group on emissions inventories (Arbeitskreis Emissionsinventare - AKEI) within the Federal Environment Agency.

At least twice per year, additional co-ordinating meetings take place between the working group at the vTI and the Single National Entity, for purposes of co-ordination and information-provision - for example, with regard to inventory improvements and research projects.

Schematic representations of the national systems relative to agriculture, LULUCF and KP-LULUCF, of the data flows for calculation of greenhouse-gas emissions and of the relevant responsibilities within those sectors are presented in Chapter 1.4.1.1.4 (Figure 13, agriculture) and Chapter 1.4.1.1.5 (Figure 14, LULUCF and KP-LULUCF).

Since the end of 2006, the Single National Entity has been working with **EUROCONTROL, the European Organisation for the Safety of Air Navigation**, on an agreement for provision of air-transport data. That agreement is to be concluded in the form of an agreement, under international law, between the Federal Republic of Germany and EUROCONTROL. A draft of the agreement was sent to EUROCONTROL in 2008. To date, EUROCONTROL has neither responded to that draft nor accepted it, however. Comparable problems exist in a number of European countries. In spring 2009, the European Commission was requested to provide assistance leading to the agreement's signing, but so far the Commission has been unsuccessful in that effort. The relevant negotiations are still pending, and they are being continued in the context of integration of air transports within the European emissions trading scheme.

Involvement of economic associations, companies and other independent organisations is achieved primarily via those departments of Federal Environment Agency divisions I and III that are responsible for pertinent concrete issues. The *Single National Entity* supports the departments in discussion of reporting requirements and in determination of requirements for data-sharing by associations. The data flows are continually reviewed by the Single National Entity and, where necessary, are safeguarded by suitable agreements between the Single National Entity and associations / business enterprises.

The Working Group on Energy Balances (AGEB) is contractually obligated, via the Federal Ministry of Economics and Technology (BMWi), to provide Energy Balances. Use of a co-ordinated schedule ensures that a provisional Energy Balance for the last reported year is prepared on time, and is transmitted to the Federal Environment Agency, by 31 July of each year, for purposes of inventory preparation.

In 2006, a sample agreement was prepared for inclusion of non-governmental agencies within the National System. That agreement is used to involve stakeholders, under binding

terms, within preparation of inventories. The sample agreement is adapted to the various data suppliers' own requirements and needs as is necessary. In July 2009, the Federal Ministry of Economics and Technology (BMWi), and the Federal Environment Agency, concluded an agreement with the German Chemical Industry Association (VCI) and German producers regarding data provision in the source categories Ammonia (2.B.1) and Nitric acid (2.B.2). In addition, agreements on data provision were reached with producers of adipic acid (2.B.3) located in Germany. Furthermore, an association agreement was concluded with the VDD industry association for bitumen paper and bitumen roof sheeting relative to the source category Bitumen for roof sheeting (2.A.5). Already in 2009, data for emissions reporting were provided in the framework of all of the aforementioned agreements.

In addition to ensuring long-term data availability, the agreements with the VCI and the VDD associations have led to considerable improvements of data quality in the relevant source categories. With these efforts, the Single National Entity is addressing the reference provided in Paragraph 18 of the 2007 Initial Review.

1.2.1.5 Directive 11/2005 of the Federal Environment Agency

In 2005, via its in-house directive (*Hausanordnung*) 11/2005, the Federal Environment Agency established a *Quality System for Emissions Inventories* (QSE) (cf. Chapter 1.3.3.1), within the Agency. The QSE provides the necessary framework for compliance with good inventory practice and for execution of routine quality assurance. This system is structured in accordance with the requirements of the *IPCC Good Practice Guidance*, and it has been adapted to national circumstances in Germany and to the internal structures and procedures of the Federal Environment Agency, the reporting institution. The in-house directive (Hausanordnung 11/2005) issues binding provisions on relevant competencies within the Agency, lists deadlines for the various inventory-preparation steps and describes the necessary relevant review actions for purposes of quality control / quality assurance.

The directive has fulfilled requirements, pursuant to Paragraph 10 (a) of the *Guidelines for National Systems*, for specification of relevant procedures, and for definition, pursuant to Paragraph 12 (c), of specific responsibilities at the Agency level.

1.2.1.6 Binding schedule in the framework of the National System

The binding schedule for preparation of emissions inventories and of the NIR is announced to all relevant internal and external stakeholders via the Federal Environment Agency's intranet site and via publication within the NIR itself:

19 May	The Federal Environment Agency's national co-ordinating agency (Single National Entity) requests relevant responsible sections to submit data and report texts
31 July	Delivery of energy data of the Working Group on Energy Balances (AGEB), of statistical data of the Federal Statistical Office and of data provided under agreements with associations and companies, where such data serve as the basis for further calculations
by 1 September	Deliveries of ready-to-use inventory data from the Federal Environment Agency and from external institutions of the NaSE
as of 2 September	Validation / discussion of deliveries by section and quality managers, taking account of review results

as of 1 October	Preparation of CRF time series and of national trend tables; final editing by the Single National Entity within the Federal Environment Agency
02 November	Internal co-ordination within the Federal Environment Agency
as of 11 November	Final quality assurance by the QSE/CSE/NIR co-ordinator
16 November	Report of the Single National Entity to the BMU, for commencement of inter-ministerial co-ordination relative to the CRF data
30 November	Report of the Single National Entity to the BMU, for commencement of inter-ministerial co-ordination relative to the National Inventory Report
17 December	Approval via departmental co-ordination (initiated by the BMU)
02 January	Final editing by the Federal Environment Agency's national co-ordinating agency (Single National Entity)
15 January	Report (CRF and certain parts of the NIR) goes to the European Commission (in the framework of the CO ₂ Monitoring Mechanism) and to the European Environment Agency
15 March	Report (corrected CRF and complete NIR) goes to the European Commission (in the framework of the CO ₂ Monitoring Mechanism) and to the European Environment Agency
15 April	Report goes to the FCCC Secretariat
May	Initial check by the FCCC Secretariat
June	Synthesis and assessment report I (by the UN Climate Secretariat)
August	Synthesis and assessment report II (country-specific; by the UN FCCC Secretariat)
September - October	Inventory review by the FCCC Secretariat

1.2.2 Overview of inventory planning

Inventory preparation draws on the expertise of **research institutions**, via execution of research projects in the UFOPLAN (environmental research plan) framework. This occurs via work on specific issues, and it takes place via overarching projects, which primarily support a) harmonisation of individual results, for the overall inventory, as well as b) identification and closure of gaps in surveys of emission-relevant activities. In each of the UFOPLANs for the 2002-2009 period, the Single National Entity had a global project on *updating emissions-calculation methods*, a framework for initiating measures for continuous inventory improvement.

In addition, a separate budget item for the National System, over and above research funding, was established within the Federal Environment Agency as of 2005 (Title 526 02, Chapter 1605). This budget item can be used to fund short-term projects for inventory improvement, within the Agency's responsibility.

1.2.3 Overview of inventory preparation and management, including overview of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

The emissions-reporting process is a regular, annual process. A decentralised process, carried out by a range of different persons, it can vary, depending what part of the inventory

is concerned. Prior to the introduction of the QSE (in 2005), this process was intensively studied and analysed. As a result of that work, within the overall emissions-reporting process, the QSE differentiates the following main processes, which are described in detail in Chapter 1.3.2:

- Definition of the bases for calculation,
- Data collection,
- Data processing and emissions calculation, and
- Report preparation.

These main processes are broken down into sub-processes (cf. Figure 6).

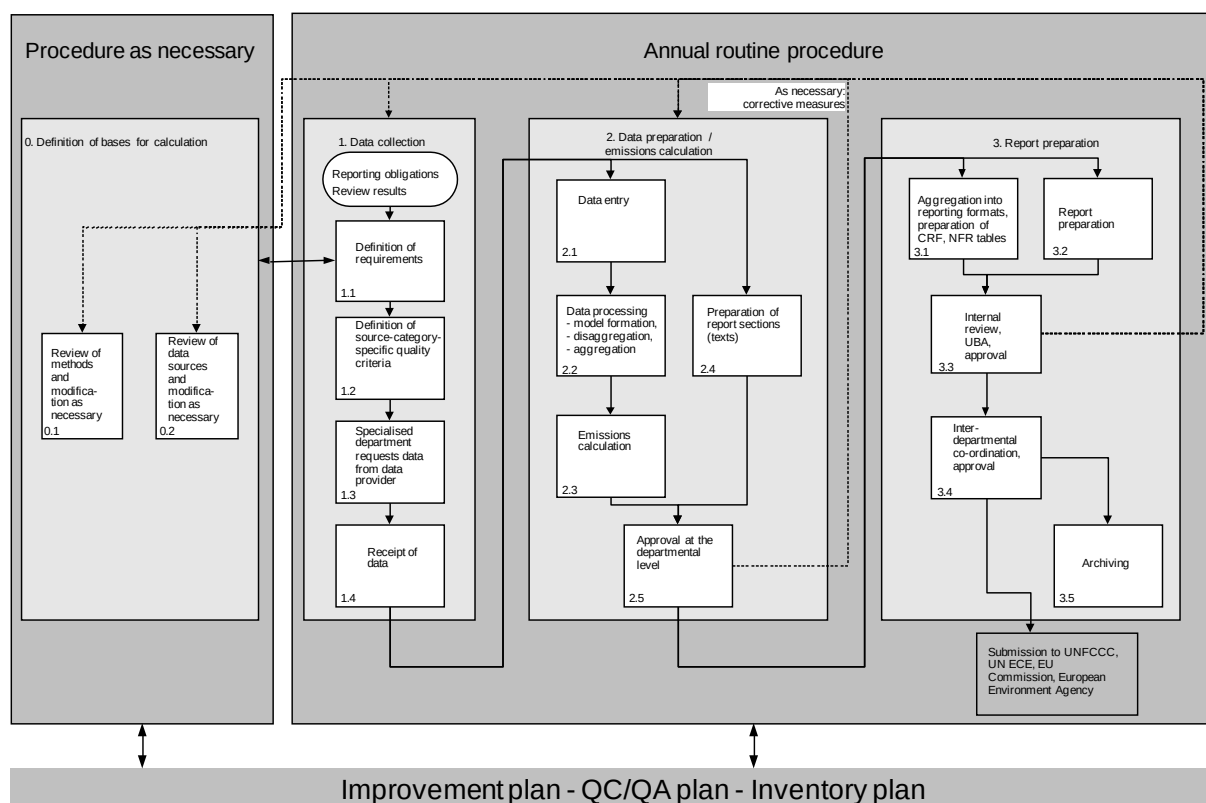


Figure 6: Overview of the emissions-reporting process

Experience has shown that workflow in the inventory planning and preparation process can affect inventory quality, i.e. that the order in which relevant steps are taken is important. That is one of the reasons why the inventory-preparation process is closely tied to quality assurance and control measures. Suitable QC/QA measures have thus been assigned to each sub-process, to ensure that quality assurance not only safeguards the quality of inventory data in its final form, but also safeguards such quality on the pathways leading to that final form. This, in turn, makes it possible to carry out periodical internal evaluations of the inventory-preparation process pursuant to paragraph 15 (d) of the *Guidelines for National Systems*.

The process, including QC/QA measures, fulfills the requirements of paragraphs 14 (a) to (g), with regard to inventory preparation, of the *Guidelines for National Systems*.

The workflow for inventory preparation is described in detail in Chapter Inventory preparation.

The reporting processes address all requirements pursuant to Article 7 of the Kyoto Protocol.

1.3 Inventory preparation

As the overview in Chapter 1.2.3 shows, inventory preparation is a regular, annual process that functions in accordance with a decentralised scheme. The processes for preparation of greenhouse-gas inventories, KP-LULUCF inventories and National Inventory Reports, and for execution of quality control and quality assurance measures, are very closely linked.

In general, the upstream processes for inventory preparation (cf. Chapter 1.3.1.1), including definition of bases for calculation (cf. Chapter 1.3.2.1), data collection and processing (cf. Chapter 1.3.2) and quality control and quality assurance (cf. Chapter 1.3.3) must be differentiated from one another.

1.3.1 Greenhouse-gas and KP-LULUCF inventories

The upstream processes of inventory preparation and definition of the bases for calculation are identical for greenhouse-gas inventories and for KP-LULUCF inventories.

1.3.1.1 Preliminary/upstream processes

Apart from the sub-processes for emissions reporting, as outlined in Figure 6, certain upstream (preliminary) processes are carried out – in each case, between a pair of emissions-reporting cycles.

The following sub-processes are considered preliminary/upstream processes:

- Continuous review and assurance of data streams from data suppliers to the Federal Environment Agency, via improvement of institutionalisation of the National System;
- Implementation of improvements in inventory planning and inventory preparation;
- Determination of key categories (pursuant to Tier 1, in keeping with Chapter 7.2 of the *IPCC Good Practice Guidance*);
- Calculation and aggregation of uncertainties relative to emissions, using Monte Carlo simulation (pursuant to Tier 1 or Tier 2, in keeping with the *IPCC Good Practice Guidance*);
- Expanded identification of key categories, via Monte Carlo simulation (pursuant to Tier 2, in keeping with Chapter 6.4 of the *IPCC Good Practice Guidance*).

1.3.1.1.1 Improvement of the National System

The National System builds on existing data streams, and it provides for suitable measures to assure long-term data provision where such assurance is lacking (cf. Chapter 1.2.1.2). Consequently, data streams continually have to be reviewed between pairs of reporting cycles.

Where voluntary commitments expire, discussions have to be carried out with the relevant data suppliers in order to secure the commitments' renewal. Where continued data provision is not assured, relevant commitments or co-operation agreements have to be obtained. In cases of any doubt, relevant legal provisions relative to data provision have to be reviewed and implemented.

Existing agreements have to be adapted as necessary to new circumstances and reporting requirements (for example, to changes in reporting procedures). Such efforts help assure the consistent high quality of the National System and the inventory preparation process.

Changes and improvements in the National System, during the current reporting cycle, are described in Chapter 13.

1.3.1.1.2 *Implementation of improvements in inventory planning and inventory preparation*

Paragraphs 13 and 15(d) of the Guidelines for National Systems (Decision 19/CMP.1) obligate all Annex I countries to strive for continual improvement of inventories and inventory planning.

Wherever possible, the required improvements identified in quality control and quality assurance, and the results of reviews, are implemented between reporting cycles.

A detailed description of the quality control and quality assurance procedures is provided in Chapter 1.6.1. The improvements achieved for the present report are described in the relevant source-category chapters.

1.3.1.1.3 *Determination of key categories (pursuant to Tier 1)*

In order to be able to focus the many and detailed activities and capacities required for inventory preparation and improvement on the principal source categories of the inventory, the IPCC has introduced the definition of a "key category/sink". Key categories/sinks are source categories that play an especially prominent role in the national inventory because their emissions/storage have a significant influence on the total emissions of direct greenhouse gases, either in terms of absolute emissions, as a contribution to the emissions trend over time, or as a result of the uncertainties linked with them.

The Single National Entity identifies key categories once per year, prior to the emissions-reporting process. Whereas in the reporting framework results are reported for year x , they cannot be taken specifically into account until inventory preparation for the year $x+1$. A source category's designation as a key category helps decide what calculation method (Tier approach) must be used for the category and, as a result, how detailed emissions modelling for the source category must be. In addition, the key-source selection process is used to identify any source categories to which priority must be given in inventory improvement.

The *IPCC Good Practice Guidance* (2000) specifies the methods to be applied in identifying key categories. These methods identify the relevant key categories with the help of analysis of the inventory for one year with regard to emissions levels for individual source categories (Tier 1 level assessment), time-series analysis of inventory data (Tier 1 trend assessment) and detailed analysis of inventory data with error evaluation (Tier 2 level and trend assessment with consideration of uncertainties).

The key categories have been defined by applying two Tier 1 procedures, Level (for the base year and for 2008) and Trend (for 2008, as compared to the base year), to German greenhouse-gas emissions. In keeping with IPCC provisions, analyses have taken account of both emissions from sources and storage of greenhouse gases in sinks.

1.3.1.1.4 *Calculation and aggregation of uncertainties relative to emissions*

Uncertainties are a basic component of emissions inventories; an emissions inventory's uncertainties are determined in order to quantitatively assess the inventory's accuracy. While uncertainties are determined in connection with data gathering, and thus are part of the "data

collection" section of the emissions-reporting process, they can be aggregated only after an inventory – or the pertinent emissions-reporting cycle – has been completed.

In calculation and aggregation of uncertainties, uncertainties for activity rates and emission factors, which are normally estimated by experts at the structural-element level of the CSE, are converted into uncertainties for emissions and then aggregated. Uncertainties are aggregated once per year, at the end of the report-preparation cycle for the current report year. Tier 2 determination of uncertainties is carried out every three years. In the years in between, uncertainties are determined in accordance with Tier 1.

In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 2 method. For Tier 2 uncertainties determination, the uncertainties have been estimated, wherever possible to date, by data-supplying experts of the relevant Federal Environment Agency specialised sections and by external institutions.

Aggregated uncertainties serve as a basis for expanded identification of key categories.

1.3.1.1.5 Expanded determination of key categories-

Expanded identification of key categories was carried out this year, in conjunction with detailed uncertainties determination via Monte Carlo simulation (in keeping with the IPCC Tier 2 method). For the German greenhouse-gas inventory, such analysis is carried out at 3-year intervals. Such work was carried out for the first time for the greenhouse-gas inventory reported in 2007 (cf. the NIR 2007). The resulting findings confirmed the results of Tier-1 key-source analysis nearly completely.

1.3.2 Data collection, processing and storage, including data for KP-LULUCF inventories

1.3.2.1 Definition of bases for calculation

Selection and review of, and (where necessary) changes in, the calculation methods used to determine emissions affect the entire emissions-reporting process. For this reason, the main process "determination of the bases for calculation" must begin with review of the suitability of the methods to be used. *IPCC Good Practice Guidance* specifies, via use of decision trees, what methods are to be used for the various source categories. In each case, such methods selection depends on whether the group in question is a key category or not. Any use of different – country-specific – methods, instead of the prescribed methods, must be justified in the NIR. In each case, an outline of why the method in question is of equivalent or higher value is to be provided, along with clear documentation.

Another factor that is critical to the success of the overall process is **selection and review of, and (where necessary) changes in, data sources**, since the quality of results of all downstream processes (data preparation, calculation, reporting) cannot be better than that of the primary data used. Data sources may be oriented to the activity rates, emission factors or emissions for/of a specific source category. In many cases, the data sources used have been relied on for a number of years. It can become necessary to select new data sources – for example, as a result of required changes in methods, of the elimination of an existing data source, of a need for additional data or of findings from quality checks of previously used data sources.

The suitability of a given data source depends on various criteria. These include:

- Long-term availability,
- Institutionalisation of data provision,
- Good documentation,
- Execution of quality assurance and control measures, by the persons/organisations providing data,
- Identification of uncertainties,
- Representative nature of the data in question, and
- Completeness of the expected data.

In each case, it is vital that the reasons for choosing a particular data source be documented and, where the data source has significant deficits, that suitable measures for improving the data be planned.

Providers of data must always be given requirements relative to quality control, quality assurance and documentation; where research projects are commissioned, this requirement is particularly relevant, since the Federal Environment Agency, as the customer for such services, must be able to influence such projects.

1.3.2.2 Data collection

Data collection and documentation take place under the responsibility of the relevant experts. One way of collecting data is to evaluate official statistics, association statistics, studies, periodicals and third-party research projects. Other ways of obtaining data include carrying out own research projects, applying personally available information and exchanging data via relevant Federal/Länder channels. Often, work results obtained by other means are also reused for the purposes of emissions reporting.

Data collection comprises the following steps:

- Definition of requirements,
- Determination of the source-category-specific quality criteria for the data,
- Requesting of data from data providers (carried out by the relevant experts' group), and
- Receipt of data.

In each case, the National Single Entity (national co-ordinating agency) also requests inventory input from the experts responsible for the source category in question, via the experts' superiors. A master file, specifying the structure for such input, is provided for NIR preparation. The requirements for later data input are provided by the relevant CSE (ZSE) specifications (direct entry or fill-in of the import format). Reporting requirements (including pertinent QC/QA measures), along with the results of all inventory reviews, the databases for the various specific source categories and the current results of key-source identification, are all communicated to the relevant experts via informational events held by the Federal Environment Agency's *Working Group on Emissions Inventories*, via the Federal Environment Agency's intranet and share-point sites for emissions reporting and via an electronic inventory description (cf. Chapter 1.3.3.1.4). On this basis, responsible experts **define requirements** with regard to both data sources and calculation methods.

Such requirements influence the upstream process of defining the bases for calculation (review and selection of methods and data sources) – a process which always takes place when requirements have not yet been fulfilled or have changed.

Before any third parties begin with data collection – after the requirements pertaining to data sources and methods have been defined – **the source-category-specific quality criteria** for such third-party data should be defined, in order to support the QC process on the data level.

When a responsible expert **requests data** from a third party able to supply data, the expert is expected to accompany his or her request with a description of the amount of data expected from the prospective data supplier, of the relevant data-quality requirements and of the relevant data-documentation requirements. Upon **receipt of data**, the data is checked for completeness, compliance with quality criteria and currentness. Data validation is carried out by the relevant expert.

1.3.2.3 Data preparation and emissions calculation

The process of data preparation and emissions calculation comprises the following steps:

- Data entry,
- Data preparation (model formation, disaggregation, aggregation),
- Calculation of emissions,
- Preparation of report sections (texts), and
- Approval by the relevant experts.

Report texts are prepared along with the time series for activity data, emission factors, uncertainties and emissions. As a result, the term "data" is understood in a broad sense. In addition to number data, time series, etc., it also includes contextual information such as the sources for time series, and descriptions of calculation methods, and it also refers to **preparation of report sections** for the NIR and documentation of recalculations.

Considerable amounts of **data entry and processing** (processing of data, and emissions calculation) take place in the CSE. This considerably enhances transparency and consistency, and it opens up the possibility of automating required data-level quality-control measures in the CSE (such as checking of orders of magnitude and of completeness, and specification of checking parameters in CalQlator). In cases that lend themselves to such automation, certain QC measures then do not have to be carried out manually. At the same time, plausibility cross-checks, with simplified assumptions, should be applied to results of calculations with complex models.

After all checks have been carried out, and the relevant parties have been consulted where necessary, the **emissions are calculated** in the CSE by means of an automated procedure, based on the following principle:

activity rate * emission factor = emission

If upstream calculation routes are also stored in the CSE, these calculations are initiated first, before the actual calculation of emissions takes place.

In each case, the relevant expert responsible for QC also has responsibility **for issuing expert-level approvals**, for written texts and for calculation results, prior to any further use of such texts and results by the Single National Entity. Such issuance normally takes place in connection with transmission to the Single National Entity, and it is carried out via approval of completed QC/QA checklists.

1.3.2.4 Report preparation

Report preparation includes the following steps:

- Aggregation of emissions data for the national trend tables and reporting formats, preparation of data tables for the NFR, export / import of XML files into the CRF reporter,
- Compilation of submitted report texts to form a report draft (NIR), and editing of the complete NIR,
- Internal review of the draft (national trend tables and NIR) by the Federal Environment Agency, followed by approval as appropriate,
- Handover to the BMU, for interdepartmental co-ordination, leading to approval by the co-ordinating committee, followed by the final steps of
- Handover to the UNFCCC Secretariat, the EU Commission and the UNECE Secretariat, and
- Archiving.

Following complete preparation of data, report sections and QC/QA checklists by the responsible experts, and transmission of those materials to the Single National Entity, the materials are reviewed by source-category-specific, specialised contact persons at the Single National Entity, on the basis of a QC checklist. The results of this review are then provided to the relevant responsible experts, to enable these experts to revise their contributions (if necessary, following suitable consultation) accordingly.

Before emissions data can be transferred into the report formats for the Framework Convention on Climate Change (CRF = Common Reporting Format), the Kyoto Protocol and the UN ECE Geneva Convention on Long-range Transboundary Air Pollution (NFR = New Format on Reporting), **emissions data** from CSE time series (in the data-collection format) must be **aggregated** into the CRF/NFR source-category **report formats**. This is accomplished via hierarchical allocation within the CSE, a process that, in Annex 3, is described in detail for the various key categories. Where no changes with respect to the previous year have occurred, the aggregations are carried out automatically.

Following calculatory aggregation, activity data and emissions are read, via export in XML-file form, into the CRF reporter, which automatically prepares the IPCC CRF reporting tables. Nonetheless, quality control still has to be carried out to ensure that the emissions inventory and the CRF-Reporter tables agree with respect to relevant values and to the implied emission factors calculated by the CRF Reporter. Furthermore, suitable explanatory remarks have to be provided for any recalculations and notation keys.

CO₂ equivalents for greenhouse gases are calculated in accordance with Art. 20 of the *IPCC Guidelines on Reporting and Review* (FCCC/CP/2002/8), on the basis of the GWP published in the *Second Assessment Report* and listed in the table below, which are based on effects of greenhouse gases out to a 100-year time horizon.

Table 3: Global Warming Potential (GWP) of greenhouse gases

Greenhouse gas	Chemical formula	1995 IPCC GWP
Carbon dioxide	CO ₂	1
Methane	CH ₄	21
Nitrous oxide	N ₂ O	310
Hydrofluorocarbons (HFC)		
HFC-23	CHF ₃	11700
HFC-32	CH ₂ F ₂	650
HFC-41	CH ₃ F	150
HFC-43-10mee	C ₅ H ₂ F ₁₀	1300
HFC-125	C ₂ H ₂ F ₅	2800
HFC-134	C ₂ H ₂ F ₄ (CHF ₂ CHF ₂)	1000
HFC-134a	C ₂ H ₂ F ₄ (CH ₂ FCF ₃)	1300
HFC-152a	C ₂ H ₄ F ₂ (CH ₃ CHF ₂)	140
HFC-143	C ₂ H ₃ F ₃ (CHF ₂ CH ₂ F)	300
HFC-143a	C ₂ H ₃ F ₃ (CF ₃ CH ₃)	3800
HFC-227ea	C ₃ H ₂ F ₇	2900
HFC-236fa	C ₃ H ₂ F ₆	6300
HFC-245ca	C ₃ H ₃ F ₅	560
Perfluorocarbons (PFC)		
Perfluoromethane	CF ₄	6500
Perfluoroethane	C ₂ F ₆	9200
Perfluoropropane	C ₃ F ₈	7000
Perfluorobutane	C ₄ F ₁₀	7000
Perfluorocyclobutane	c-C ₄ F ₈	8700
Perfluoropentane	C ₅ F ₁₂	7500
Perfluorohexane	C ₆ F ₁₄	7400
Sulphur hexafluoride		
Sulphur hexafluoride	SF ₆	23900
Additional Greenhouse Gases		
<i>HFC 245fa</i>	<i>C₃F₅H₃ (CF₃CH₂CHF₂)</i>	<i>950</i>
<i>HFC 365mfc</i>	<i>C₄F₅H₅ (CF₃CH₂CF₂CH₃)</i>	<i>890</i>
<i>NF₃</i>	<i>NF₃</i>	<i>8000</i>

Source (except for entries in italics): FCCC/CP/2002/8, p.15

At the same time, the report co-ordinator **compiles the checked report texts into the draft** of the NIR.

Review and approval, within the Federal Environment Agency, of the completed report tables and the NIR, and of the inventory plan to be included in future, is provided via co-signing in the framework of the **Federal Environment Agency's internal co-ordination process**. Then, the materials are **forwarded** to the BMU, for the second approval phase within the framework of **interdepartmental co-ordination**. In a concluding step, the co-ordinating committee approves the report tables and the NIR for submission to the UNFCCC Secretariat. The ministry arranges for translation of the NIR and for its **submission to the UNFCCC Secretariat**.

The data tables and the related NIR, in the version provided for ministerial co-ordination, are then transferred onto a CD and archived with clear identification information. The content of the CSE database used for calculation purposes is likewise copied and archived. The final version submitted to the Secretariat of the Framework Convention on Climate is also **archived**.

1.3.3 Procedures for quality assurance and quality control (QA/QC), and detailed review of greenhouse-gas and KP-LULUCF inventories

1.3.3.1 The Quality System for Emissions Inventories

The QSE takes account of provisions of the *IPCC Good Practice Guidance*, of national circumstances in Germany and of the internal structures and procedures of the Federal Environment Agency (UBA), the reporting institution. The QSE's procedures are flexible enough to be able to routinely incorporate future changes in requirements. The QSE's scope of application comprises the entire emissions-reporting process.

The QSE covers all participants of the NaSE. Within the Federal Environment Agency, the QSE has been made binding via the agency's internal directive (UBA-Hausanordnung) 11/2005 (cf. Chapter 1.2.1.5). Details regarding assurance of the QSE's binding nature for other NaSE participants are provided in Annex 22.1.1.

1.3.3.1.1 Minimum requirements pertaining to a system for quality control and assurance

The requirements pertaining to the system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" (cf. Chap. 22.1.2.1). Other National System participants adopted the minimum requirements after representatives of the participating federal ministries approved them in the framework of the co-ordinating committee for the National System of Emissions Inventories (cf. Annex Chap. 22.1.1).

Further information regarding the Federal Environment Agency's necessary organisational measures for implementing these requirements is provided in the following chapters and in a complementary section in the Annex, 22.1.2.1.11.

1.3.3.1.2 Start-up organisation for establishing the Quality System for Emissions Inventories

Within the QSE framework, a concept for a start-up organisation was developed that defines binding responsibilities, for the Federal Environment Agency, for implementation of the necessary QC and QA measures. The defined roles and responsibilities have the purpose of facilitating effective information exchange and directive-conformal execution of QC and QA (cf. Table 4).

Table 4: QSE – Roles and responsibilities

Role	Tasks	Responsible
Responsible expert at the operational level (FV)	Data collection, entry and calculation, in keeping with the prescribed methods Definition of source-category-specific quality and review criteria Execution of QC measures Decentralised archiving of source-category-specific inventory information	All staff appointed by the head (FGL)
QC/QA section representative (QKV)	QC for data and report sections delivered to the Single National Entity (SNE) Approval of report sections Ensuring that necessary inventory work, QC measures and documentation are carried out at the operational level Definition of specific sectional emissions-reporting responsibilities, and follow-up to ensure they are properly carried out	All responsible heads (Federal Government and the Länder)
Specialised contact person (source-category-specific) in the SNE (FAP)	Facilitation of specialised and technical support (inventory work and reporting) Independent QC/QA for supporting work of the various sections	An appointed staff member of the Single National Entity (SNE)
Report co-ordinator (NIRK)	Co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR	An appointed staff member of the Single National Entity (SNE)
CSE co-ordinator (ZSEK)	Overarching QC and QA throughout the entire inventory process Ensuring the integrity of databases Emissions reporting and data aggregation into report formats	An appointed staff member of the Single National Entity (SNE)
QC/QA co-ordinator (QSEK)	Overarching QC and QA throughout the entire reporting process Maintenance and further development of the QSE Management and updating of the QC and QA plans, QC checklists and QSE manual Management and updating of the improvement plan, and management of relevant adoption in the inventory plan	An appointed staff member of the Single National Entity (SNE)
NaSE co-ordinator (NaSEK)	Ensuring of on-time, requirements-conformal reporting Initiation of overarching measures from the inventory plan Selection of institutions and collection of relevant informational materials and legal agreements Ensuring that all inventory information is archived, carrying out central archiving of inventory information Preparation of execution and post-processing of inventory reviews	An appointed staff member of the Single National Entity (SNE)
Contact persons in Federal Environment Agency departments	Multipliers for departments and sections with regard to the national co-ordinating agency (SNE) information's and requirements relative to emissions reporting	An appointed member of each relevant Federal Environment Agency department

1.3.3.1.3 Organisation for establishing the Quality System for Emissions Inventories

Procedures for QC/QA measures in the QSE are oriented to the emissions-reporting process described in Chapter 1.2.3. At the same time, quality management is directly linked with the various steps in the inventory process. Suitable QC measures, assigned to the various process players, have been allocated to each step of the inventory-preparation process (cf. Table 7).

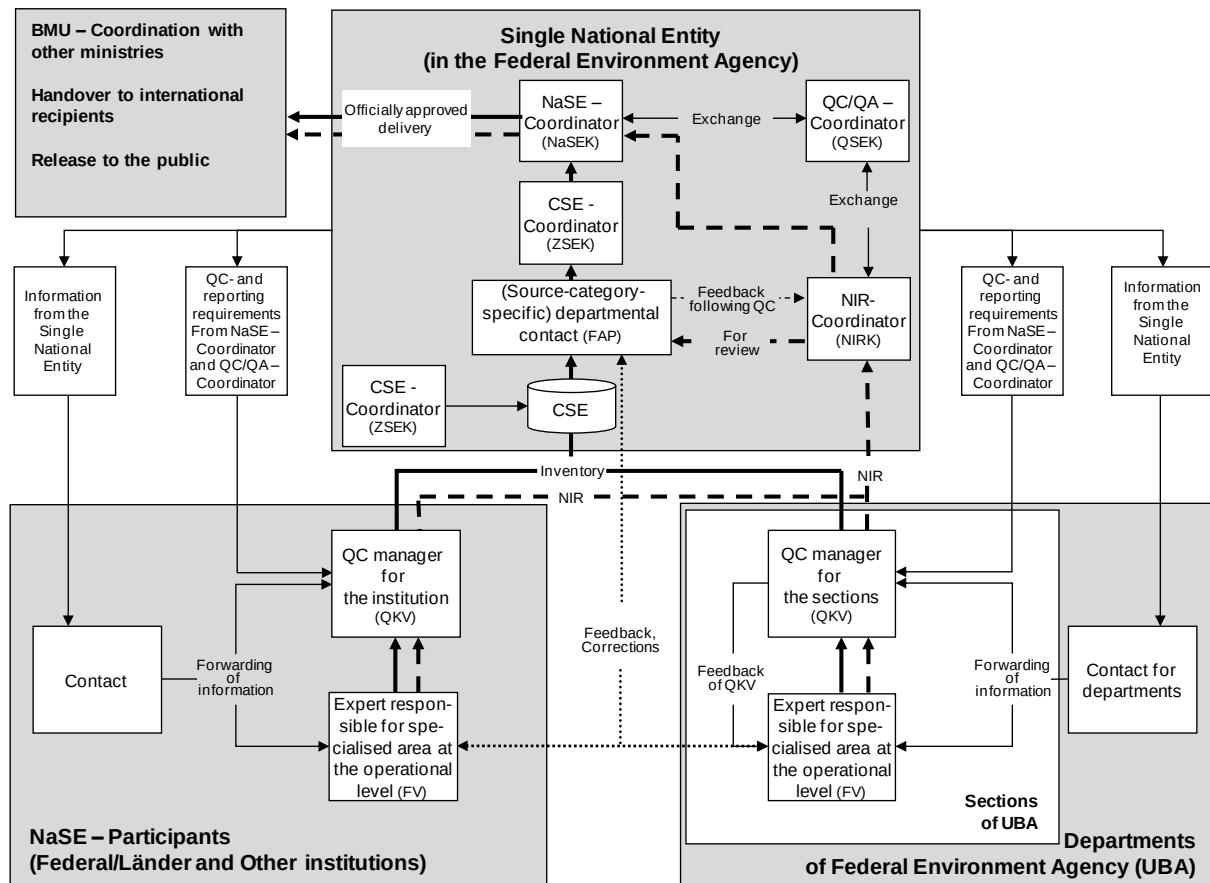


Figure 7: QSE – Roles, responsibilities and workflow

The required quality reviews pursuant to Paragraph 14 (g) of the *Guidelines for National Systems* are provided, in the form of quality checklists and along with data requirements, to the FV, QKV, FAP and NIRK (cf. Table 4). They are completed in the course of the relevant supporting work.

1.3.3.1.4 Documentation in the Quality System for Emissions Inventories

The requirements pertaining to the execution, description and documentation of QC/QA measures, as formulated in connection with the minimum requirements for a QC/QA system (cf. Chapter 22.1.2.1) are largely being fulfilled in conjunction with production of the pertinent inventory contributions. For the QSE, a documentation concept was developed that represents all such measures and related actions in an integrated form tailored to the specific parties and tasks concerned. The various components of such documentation are shown in Figure 8.

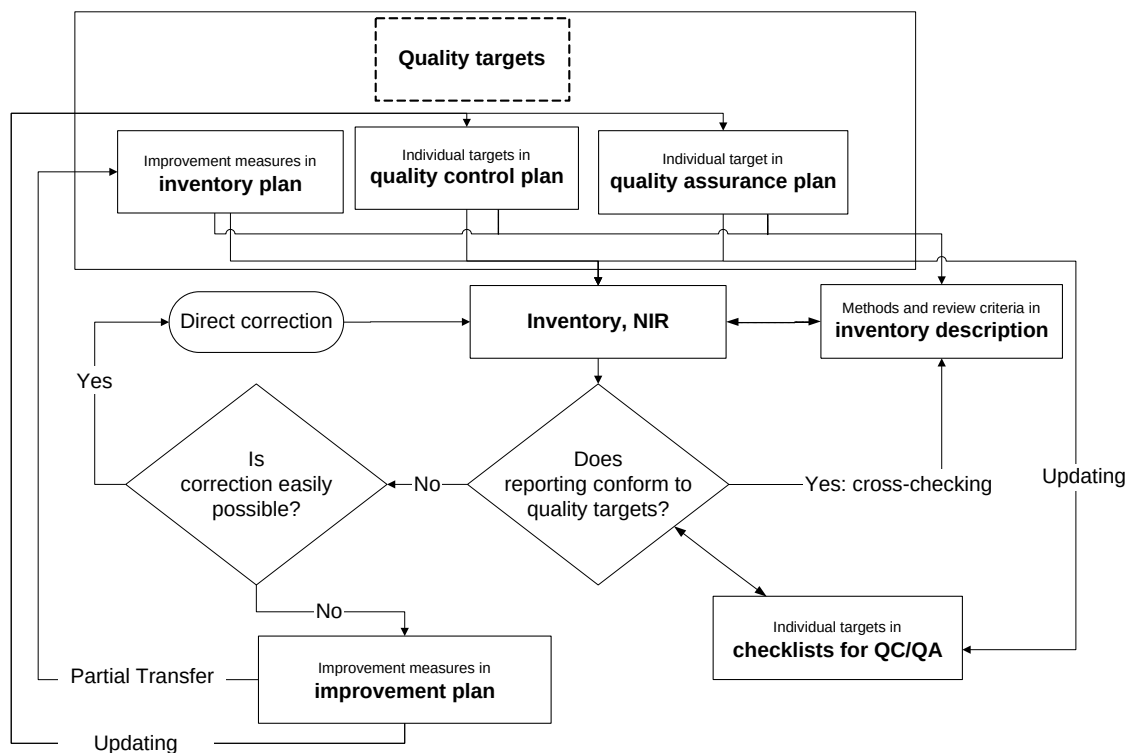


Figure 8: NaSE & QSE – Control and documentation

A general description of the **Quality targets** is provided in the QSE handbook; the description is derived from the *IPCC Good Practice Guidance*¹¹. In addition, individual operational objectives, relative to quality control and quality assurance, have to be derived for the various source categories from comparison of the requirements from the *IPCC Good Practice Guidance*, the results of independent inventory review and assessment of inventory realities.

Pursuant to the IPCC Good Practice Guidance requirements and Paragraph 12 (d) of the *Guidelines for National Systems*, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and monitoring such QC/QA measures. To permit transparent, effective control of execution and monitoring of measures for achieving these objectives, the measures are set forth in a **quality control plan (QC plan)** and a **quality assurance plan (QA plan)** with respect to specific roles – and, if necessary – specific source categories. Quality assurance objectives may be focused on the inventory, the reporting process or the QSE itself. Furthermore, the quality assurance plan includes scheduling of quality assurance measures to be performed by independent, external third parties. Both plans may be understood as sets of specifications.

As to their document structure, the QC and QS plans are combined with the **checklists for quality control and quality assurance**, which are used to review and document successful execution of quality controls. In this context, quality checks are actually defined not as checks but as quality objectives; in each case, either compliance with the objectives must be confirmed or non-compliance must be justified. Such QC/QA checklists are to be filled out by

¹¹ For relevant explanations / definitions, see also Annex 3 (Glossary) of the *IPCC Good Practice Guidance*

NaSE participants¹² along with inventory preparation. They are designed to provide information about the quality of the data and methods on which the inventory is based. The first time the Federal Environment Agency carried out systematic QC/QA, in the form of checklists, and in co-operation with the NaSE participants, was for the 2006 report. Since the 2007 report, these checklists have been used in electronic form. Also as of the 2007 report, in a first step, Tier 1 QC checks have been expanded to include category-specific QC checks in accordance with Tier 2, for key categories. For the 2008, 2009 and 2010 reports, the checklists for the experts involved in the various specialised areas, and for specialised contact persons, have been comprehensively revised. Such revision has been aimed at further enhancing the clarity, practical usefulness and logical structure of the checklists. To ensure the success of the pertinent improvements, a number of persons from the affected group of persons were selected for inclusion in the revision process. No changes were made in content-relevant requirements, which are derived from the IPCC Good Practice Guidance. Just as the checklists have been annually revised and improved, so have the QC and QA plans been continually refined.

Taken together, the two plans and the QC checklists are an instrument for reviewing fulfillment of international requirements, and they make it possible to control inventory quality via initiation of quality assurance measures pursuant to Paragraph 13 of the *Guidelines for National Systems*.

The **improvement plan** is a collection of all potential improvements, and criticisms, that result from independent inventory review and are identified in the framework of the relevant last completed emissions-reporting cycle. In the plan, such improvements and criticisms are correlated with feasible corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, via consultations with the relevant responsible experts, integrates them as necessary within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process. It is thus a binding set of specifications for improvements to be carried out in the coming reporting year.

The Single National Entity also maintains an **inventory description**, a central document record for the various source categories. The description covers all key aspects of inventory preparation. It includes descriptions of all work that pertains to specific source categories and that is relevant to preparation of source-category-specific inventories. The inventory description is really a collection of background information. It is divided into a **paper-form inventory description** and an **electronic inventory description (eIB)**. The two versions are identical in structure. Both are managed by the Single National Entity, and both cover all of the document types currently used in everyday inventory work. The obligation to prepare defined documentation was introduced in the Federal Environment Agency via an internal directive (cf. Chapter 1.2.1.5). It provides the key basis for archiving inventory information pursuant to the provisions of Paragraph 16 (a) of the *Guidelines for National Systems*.

¹² These persons include specialised experts (Fachverantwortliche - FV), specialised contact persons (Fachliche Ansprechpartner - FAP), quality control managers (Qualitätskontrollverantwortliche - QKV), the co-ordinator for the national inventory report (Koordinator für den Nationalen Inventar Report - NIRK), the co-ordinator for the National System (Koordinator für das Nationale System - NaSEK), the co-ordinator for the Central System of Emissions (Koordinator für Das Zentrale System Emissionen - ZSEK) and the co-ordinator for the Quality System for Emissions Inventories (Koordinator für das Qualitäts-System Emissionsinventare - QSEK)

For a range of reasons, the *documentation concept, in a departure from* Paragraph 17 of the *Guidelines for National Systems*, does not provide for an exclusively central archive. The key reasons for this decision were:

- the body of data that provides the basis for calculating the German inventory is extensive, and non-centralised,
- responsibility for that data is distributed,
- confidentiality aspects that, for legal reasons, preclude provision of individual data, for archiving purposes, to a central agency.

The central archive also includes a suitable reference system for relevant, but non-archived data. That system records "who has non-centrally archived what data where", and in what form such data were aggregated for the inventories.

1.3.3.1.5 *The QSE handbook*

The international requirements for quality assurance and quality control measures in emissions reporting have been set forth, for the National System of Emissions Inventories (NaSE) in Germany, in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 280/2004/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG". That document, which is binding for the Federal Environment Agency, describes the Quality System for Emissions Inventories (QSE).

The QSE handbook has entered into force via an in-house directive of the Federal Environment Agency (cf. Chapter 1.2.1.5). It has been published, along with pertinent, co-applicable documents, in the Federal Environment Agency's intranet.

The pertinent, co-applicable documents include:

- a list of specialised contact persons in the Single National Entity,
- a list of relevant contact persons in the agency's departments,
- a list of responsible persons in the Federal Environment Agency's relevant sections (section contacts – Fachverantwortliche),
- the quality control plan,
- the quality assurance plan,
- the role-specific QC/QA checklists,
- the improvement plan and the inventory plan,
- the requirements for reporting from the Guidelines,
- the results of inventory reviews,
- the available specific data for each source category (inventory description),
- the results of determination of the key categories (pursuant to Tier 1 and (if necessary) Tier 2),
- the NIR,
- the guide for calculation of uncertainties,
- a form for proposals relative to ongoing improvement of the QSE, and
- a guide to using the QSE checklists.

1.3.3.1.6 Support provided by expert-review groups

In addition to the Federal Environment Agency's own quality control and assurance measures, inventory review by expert review groups provides important impetus for inventory improvement. It is thus in the Single National Entity's own interest to fulfil the provisions of Paragraphs 16 (b) and (c) regarding provision of archived inventory information for the review process and for responding to questions of expert review groups. This relationship has been given priority in the design of the QSE. For this reason, since 2004 all tabular-form correspondence relative to inventory reviews, along with the pertinent German answers, and together with relevant documents from national QC/QA, has been archived in a searchable format.

1.3.3.1.7 Use of EU ETS monitoring data for improvement of GG-emissions inventories

Monitoring data from the European Emissions Trading Scheme (ETS) will be used to improve the quality of annual national emissions inventories with respect to source categories that include installations subject to reporting obligations under the ETS CO₂ Emissions Trading Scheme.

The comparisons have confirmed, in principle, the usefulness of such comparisons for verifying individual source categories and identifying data gaps. A formalised procedure, with defined deadlines and workflow, has been agreed for their regular use and for the relevant annual required data exchanges.

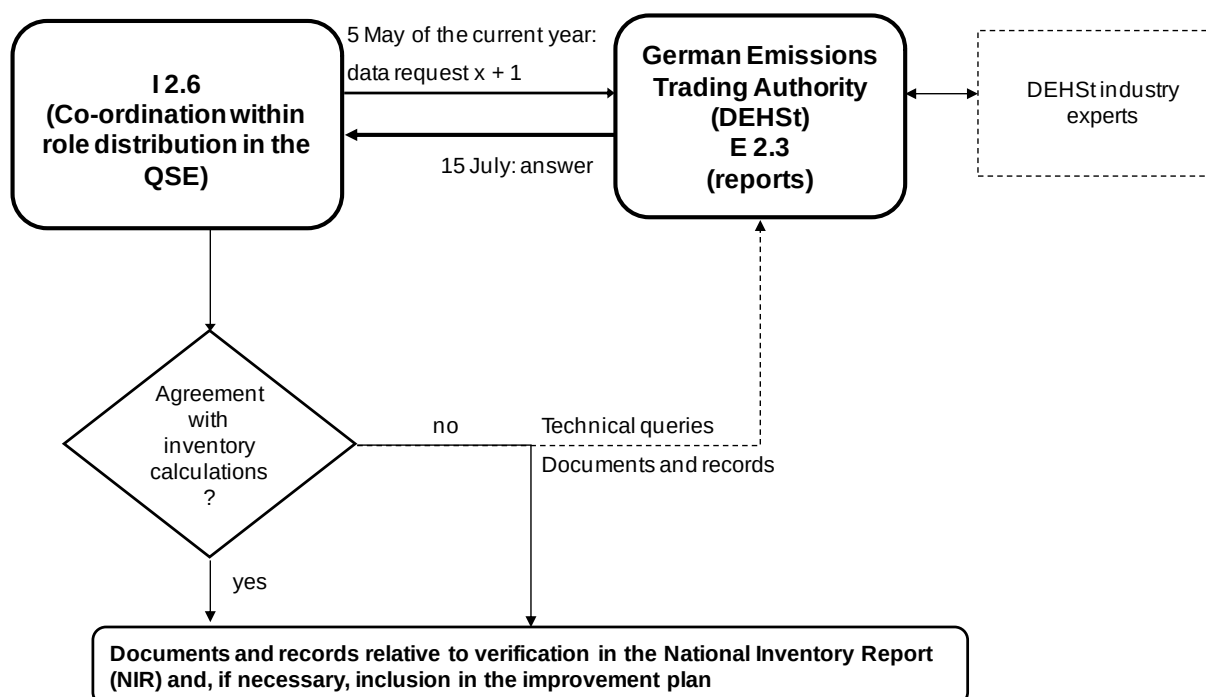


Figure 9: Procedural flow for annual inventory verification using ETS monitoring data

1.4 Short, general description of the methods and data sources used

1.4.1 Greenhouse-gas inventory

1.4.1.1 Data sources

1.4.1.1.1 Energy

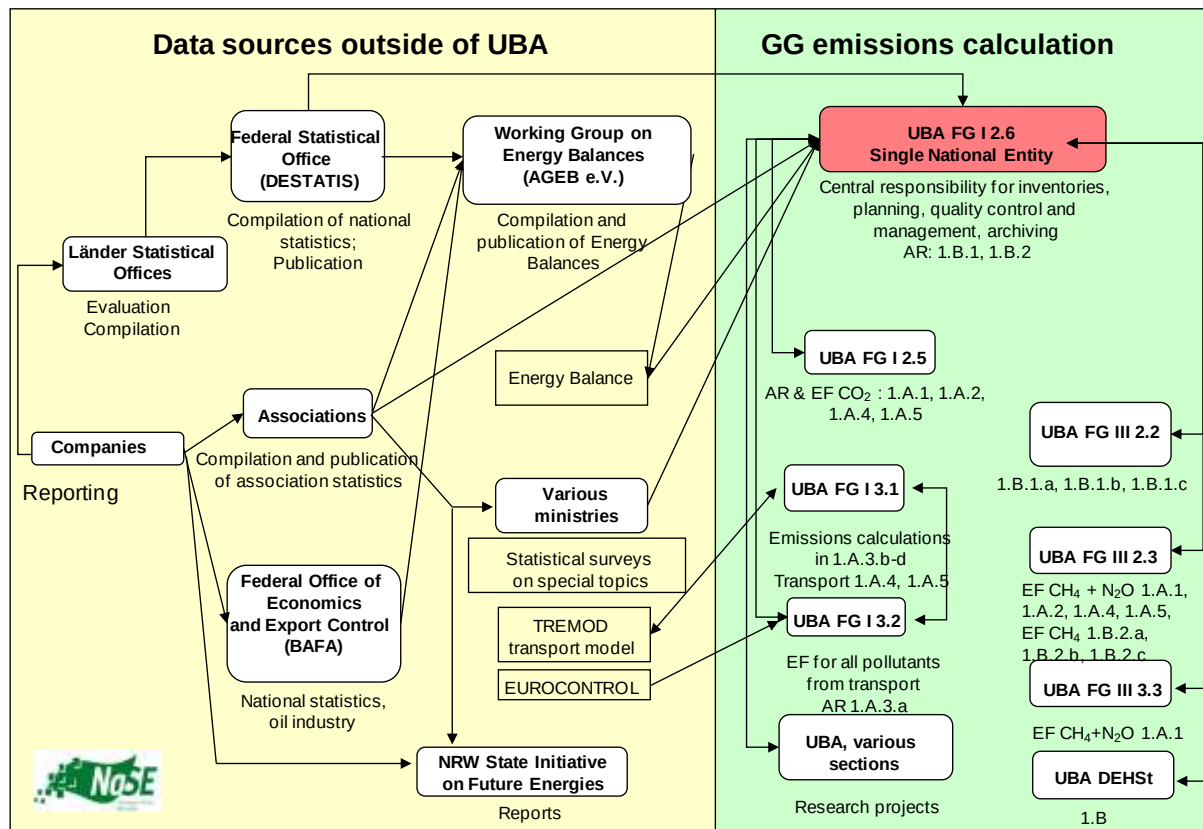


Figure 10: Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector

In all likelihood, the most important data sources for determination of activity rates for source category 1.A are the "*Energiebilanzen der Bundesrepublik Deutschland*" (Energy Balances of the Federal Republic of Germany, hereinafter referred to as: Energy Balance), which are published by the *Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen - AGEB)*. An energy balance provides an overview of the links within Germany's energy sector, and it supports breakdowns in accordance with fuels and source categories. An energy balance receives data from a wide range of other sources.

In commissioning the Energy Balances 2007 – 2012, the BMU obligated the Working Group on Energy Balances (AGEB) to comply with minimum requirements pertaining to quality assurance for the National System. In addition, for the most recent year's Energy Balance, quality reports of the German Institute for Economic Research (DIW) and of Energy Environment Forecast Analysis GmbH Co. KG are available that describe relevant measures for quality assurance and quality control.

Along with the main Energy Balance, a *Satellite Balance of Renewable Energies (Satellitenbilanz Erneuerbare Energieträger; hereinafter referred to as: Satellite Balance)*

also appears. This balance describes the growth and use of renewable energies in detail. The Satellite Balance appears together with the Energy Balance.

Also along with the Energy Balance, the Working Group on Emissions Balances (AGEB) also publishes "Evaluation Tables for the Energy Balance" (*Auswertungstabellen zur Energiebilanz* (hereinafter referred to as: evaluation tables). In the area of fuels, these tables only list those fuels with the highest activity levels and aggregate lower activity levels to form sum values (such as *other solid fuels*). Breakdowns according to specific source categories are limited largely to source categories that consume final energy (such as *manufacturing sector* or *transport*). Some source categories are not listed (such as *production of district heat*). The evaluation tables are published relatively promptly (in the summer of the relevant subsequent year). The tables can be used to determine aggregated activities at the source-category levels for the most commonly used fuels. Further disaggregation can be achieved via formation of relevant differences using other statistics.

Another important data source for determination of activity rates consists of *Fachserien 4 Reihe 4.1.1, Reihe 6.4, Reihe 8.1* (especially, the so-called "BGS form") and, for waste data, *Fachserie 19* of the *Federal Statistical Office*. These publications contain data on production-related fuel consumption, and on facilities and plants, in the manufacturing and mining sectors. These data are published relatively promptly after collection (about one year), and they are broken down finely in accordance with various areas of the manufacturing sector. To support further data differentiation, and clarification of details, the Federal Statistical Office provides special evaluations.

For the iron and steel sector, the so-called "BGS form" (Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations), an unpublished section of "Fachserie 4, Reihe 8.1", is used. The surveys in that framework end in 2010, and efforts are underway to establish a substitute survey.

The series STATISTIK DER KOHLENWIRTSCHAFT ("Coal industry statistics"), especially its annual publication "Der Kohlenbergbau in der Energiewirtschaft der Bundesrepublik Deutschland" ("Coal mining in the energy sector of the Federal Republic of Germany"), is used as an additional data source. In addition, the special evaluations provided by the Bundesverband Braunkohle (DEBRIV; federal German association of lignite-producing companies and their affiliated organisations) are used for differentiation of the different types of raw lignite coal that are burned. Furthermore, DEBRIV provides the necessary data for calculation of fuel inputs for lignite drying.

Yet another data source is the publication "Mineral-Oil Data" (*Mineralöl-Zahlen*) of the Association of the German Petroleum Industry (*Mineralölwirtschaftsverband; (MWV) e.V.* (hereinafter also referred to as: MWV Statistics)). This publication contains data on supply and consumption of petroleum in Germany, and it is broken down by source categories. The statistical data as published is very current (publication takes place within just a few months after the relevant survey).

The quantities of secondary fuels used for energy generation (listed under CRF 1.A.2) are taken from the annual report of the German Pulp and Paper Association (Verband der Papierindustrie) and from reports of the German Cement Works Association (Verband der Zementindustrie – VDZ).

The emission factors for source category 1.A were provided by research projects, initiated by the Federal Environment Agency, of the Öko-Institut (Institute for Applied Ecology) and the Franco-German Institute for Environmental Research (DFIU).

For collection of transport emissions data (1.A.3), *Official Mineral-oil Data (amtliche Mineralöl-daten)* of the Federal Office of Economics and Export Control (BAFA) and *Mineral-oil Data (Mineralöl-Zahlen)* of the Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry (MWV) e.V. are used, in addition to Energy Balance data.

Road-transport emissions are calculated primarily with the TREMOD model ("*Transport Emission Estimation Model*"; currently: Version 5.1, IFEU, 2010)¹³. For calculations carried out in TREMOD, extensive basic data from generally accessible statistics and special surveys are used, co-ordinated, and supplemented. A precise description of the data sources for emission factors is provided by the "Handbook of road-traffic emission factors" ("*Handbuch Emissionsfaktoren des Straßenverkehrs*"; INFRAS 2004).

For air transports, in addition to data of the aforementioned sources, data of *EUROCONTROL, the European Organisation for the Safety of Air Navigation*, and of the *Federal Statistical Office* are used: Year-specific split factors, determined on the basis of actual aircraft movements, are used to break down fuel consumption and emissions data by national and international air transports. For years as of 2003, the split factors are provided by Eurocontrol. For all earlier years, they are derived via aircraft-movement data (numbers of take-offs and landings) collected by the Federal Statistical Office. The aircraft-movement data collected by the Federal Statistical Office is also used to break down consumption and emissions data in accordance with the different phases of flight.

Data on emissions of other mobile sources (in 1.A.4.b & c and 1.A.5.b) are also collected from figures of the Working Group on Energy Balances (AGEB), of BAFA and of the Association of the German Petroleum Industry (MWV). Military transports (1.A.5.b) play a special role in this context; all of the consumption data for those transports are taken from the Official Mineral-oil Data of BAFA, since such data are no longer listed separately in the Energy Balances.

Data for source categories of category 1.B.1 are taken from publications of Statistik der Kohlenwirtschaft e.V. (coal-industry statistics), the Federal Ministry of Economics and Technology (BMWi), the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, Deutsche Montan Technologie GmbH (DMT), the German Society for Petroleum and Coal Science and Technology (DGMK) and Interessenverband Grubengas e.V. (IVG; association for the pit-gas sector).

The publication "Statistik der Kohlenwirtschaft" (coal-industry statistics) is especially important in this context. It is processed with the help of federal and Land (state) ministries, including their authorities (such as supreme state mining authorities), and with use of reports and expert opinions of the "Landesinitiative Zukunftsenergien" NRW ("*NRW State Initiative for Future Energies*"; here, the AG Grubengas pit-gas working group). Inventory preparation is co-ordinated with the support of the Association of the German hard-coal mining industry (Gesamtverband Steinkohle; formerly, Gesamtverband des deutschen Steinkohlebergbaus - GVSt).

13 To make it possible to derive and assess reduction measures, energy consumption and CO₂ emissions for the various vehicle categories are also calculated with TREMOD. The resulting values are subsequently checked against total consumption and total CO₂ emissions.

Data for source categories in category 1.B.2 are taken from publications of the *Federal Statistical Office*, the Association of the German Petroleum Industry (MWV), the German Society for Petroleum and Coal Science and Technology (DGMK), the Association of the petroleum and natural-gas industry (Wirtschaftverband Erdöl und Erdgasgewinnung e.V. - WEG), the German Technical and Scientific Association for Gas and Water (DVGW), the Federal association of the German gas and water industry (Bundesverband der deutschen Gas- und Wasserwirtschaft - BDEW; gas statistics) and the German Emissions Trading Authority (DEHSt). Processing in this area now takes account of responses (statements of position) of the WEG.

1.4.1.1.2 Industrial processes

Activity data for the mineral industry are obtained primarily from association statistics. The data for the cement industry (2.A.1) were provided by the German Cement Works Association (Verband der Zementindustrie – VDZ), especially by that association's research institute, as well as by the Federal association of the German cement industry (Bundesverband der Deutschen Zementindustrie e.V. - BDZ). For the most part, the data in question consist of data published in the framework of CO₂ monitoring under the industry's voluntary climate-protection commitment. The figures for lime and dolomite-lime production (2.A.2) are collected by the German Lime Association (BVK) on a per-plant basis and then provided annually in aggregated form. Use of limestone and dolomite (2.A.3) is reported in other source categories (included elsewhere); the pertinent data sources are noted in the relevant categories. The total quantity of soda ash production (2.A.4) is determined via surveys of the Federal Statistical Office, while soda ash use (2.A.4) is determined via assessment by experts of the Federal Statistical Office. The production quantities for bitumen paper and bitumen roof sheeting (2.A.5) are provided by the VDD industry association for bitumen paper and bitumen roof sheeting. Production quantities of asphalt for road paving (2.A.6) are provided by the German asphalt association (Deutscher Asphaltverband - DAV). Glass-production figures (2.A.7 Glass) are taken from the regularly published annual reports of the Federal glass industry association (Bundesverband Glasindustrie), although relevant orientational figures on glass recycling are taken from other statistics. Production trends in the ceramics industry (2.A.7 Ceramics) are determined via official statistics and via conversion factors provided by the Federal association of the German brick industry (Bundesverband der Deutschen Ziegelindustrie).

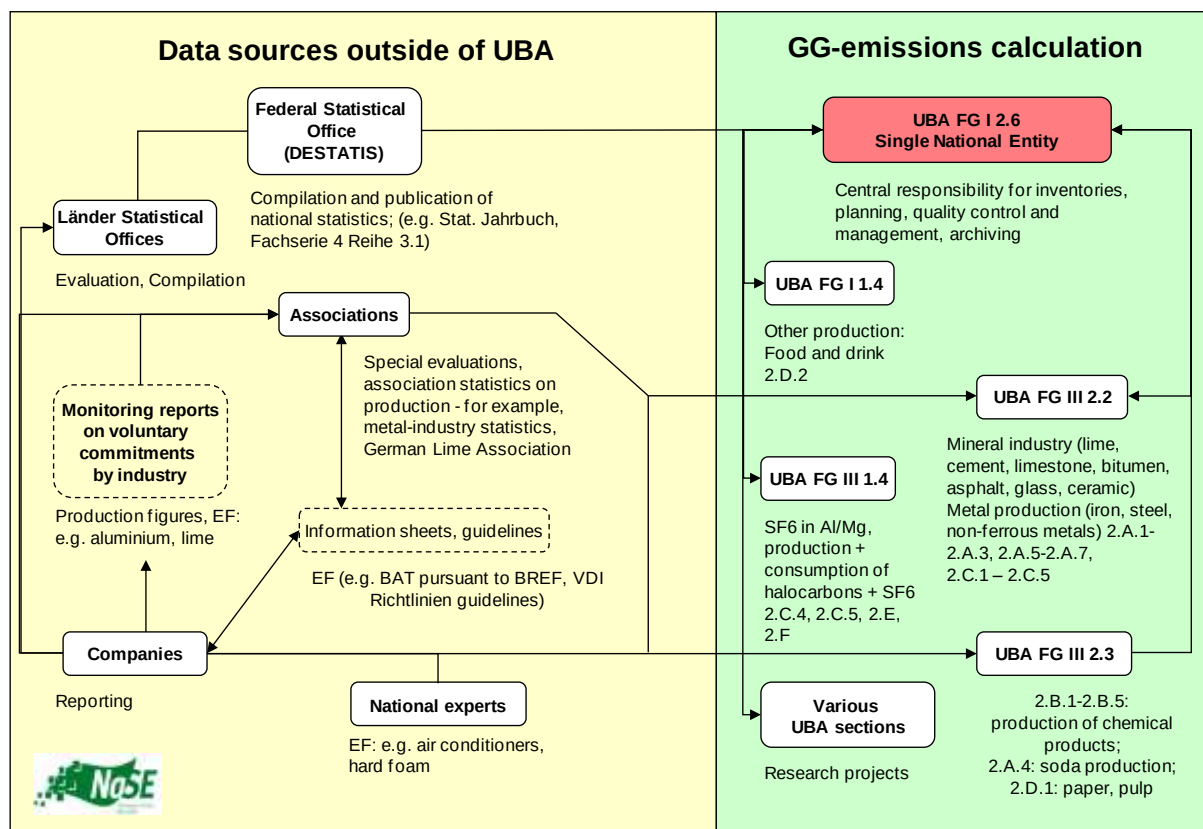


Figure 11: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes

A range of different sources are used to determine emission factors for the mineral industry. The emission factor used for calculation of emissions from cement-clinker production (2.A.1) is based on a calculation of the German Cement Works Association (VDZ) carried out by aggregating plant-specific data. CO₂ emissions from lime production (2.A.2) and from soda-ash use (2.A.2) are calculated with the help of stoichiometric factors. Soda ash production (2.A.4) via the Solvay process is considered CO₂-neutral with regard to the raw materials used. The emission factors for production and laying of bitumen paper and bitumen roof sheeting (2.A.5), and for production of asphalt for road paving (2.A.6) refer only to NMVOC, and they have been taken from research reports. The CO₂-emission factors for various types of glass (2.A.7 Glass) have been derived from glass-composition data, while CO₂-emission factors for the ceramics industry (2.A.7 Ceramics) have been derived, by Federal Environment Agency experts, from raw-material inputs.

The activity data for source category 2.B Chemical industry are determined from data of the *Federal Statistical Office*, of the *Mineralölwirtschaftsverband e.V.* Association of the German Petroleum Industry and directly from figures of industry associations and producers. The latter group (industry data) is confidential. The relevant emission factors have been determined by experts in the Federal Environment Agency, via research projects or by the pertinent producers. Until 2008, activity data for 2.B.1 Ammonia production and 2.B.2 Nitric acid production were collected by the *Federal Statistical Office*. Since 2009, data for ammonia and nitric-acid production have been collected by producers themselves – plant-specifically, on the basis of an agreement with the chemical industry and for the entire time series as of 1990. These data are forwarded to the association, which aggregates them and forwards them to the Federal Environment Agency. The emission factors for 2.B.2 have been determined by the producers. For 2.B.1, producers provide the activity rates and emissions

data. Until the mid-1990s, plant-by-plant activity data were supplied for 2.B.3 Adipic acid production. The default emission factor for N₂O was applied to that data. Now, plant operators are supplying emissions data directly to the Federal Environment Agency, on a confidential basis. For the area of adipic-acid production, data delivery has also been assured for the long term, via an agreement from 2009. At present, producers in Germany find the IPCC's default emission factors for NO_x, CO and NMVOC rather puzzling. This is the reason why emissions of these substances have not been reported to date. Since there is only one calcium carbide (2.B.4) producer in Germany, the relevant data are confidential. The Federal Environment Agency obtains these data directly from the producer. Under 2.B.5 Other, emissions from several different production processes are reported: Production of sulphuric acid, titanium dioxide, organic substances, soot and other products. The activity data have been obtained via research projects, data of the Federal Statistical Office and publications of the Association of the German Petroleum Industry. The emission factors have been obtained from experts' assessments, research projects and default figures in the IPCC Guidelines.

The activity data for the metal industry (2.C) are provided by the *Federal Statistical Office* and the relevant associations (Steel Institute VDEh, Wirtschaftsvereinigung Metalle (metals industry association) and Gesamtverband der Aluminiumindustrie (aluminium industry association)). The emission factors for the metals industry (2.C) are normally calculated by experts in the Federal Environment Agency; in some cases, IPCC default values are used as well.

One exception in this regard is the source category Ferroalloys (2.C.2); for it, activity data from statistics of the U.S. Geological Survey are used, while the relevant emission factors have been provided by a research project.

In the area of Other production: Pulp and paper production (2.D.1), data from the production report of the German Pulp and Paper Association (Verband Deutscher Papierfabriken VDP) are used. In the area of Other production: Food and beverages (2.D.2), data of the Federal Food Industry Association (Bundesvereinigung der Deutschen Ernährungsindustrie; BVE), of the Federal Statistical Office (Statistisches Bundesamt) and of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) are used.

In the area of production of halocarbons and SF₆ (2.E), data are obtained from *producers' figures and surveys of producers*. For the most part, activity data are researched in the framework of research projects, directly in accordance with the inventory's requirements. In some cases, producers supply only emissions data. Only small numbers of companies are involved in the various sub- source categories, and thus data in these areas are confidential.

The activity data for consumption halocarbons and SF₆ (2.F) are determined from figures of producers and associations, from surveys of the Federal Statistical Office and of other federal authorities and with the help of calculation models. In individual cases, producers provide emissions data directly. The data are classified into several sub - source categories. Furthermore, a distinction is made between production, use and disposal emissions. The data in some parts of 2.F are also confidential.

Emission factors for source categories 2.E and 2F are obtained in part from national and international fact sheets and directives or via surveys of experts; where necessary, IPCC default values are used.

More detailed pertinent information regarding emission factors is presented in the descriptions of methods for the various source categories.

1.4.1.1.3 Solvent and other product use

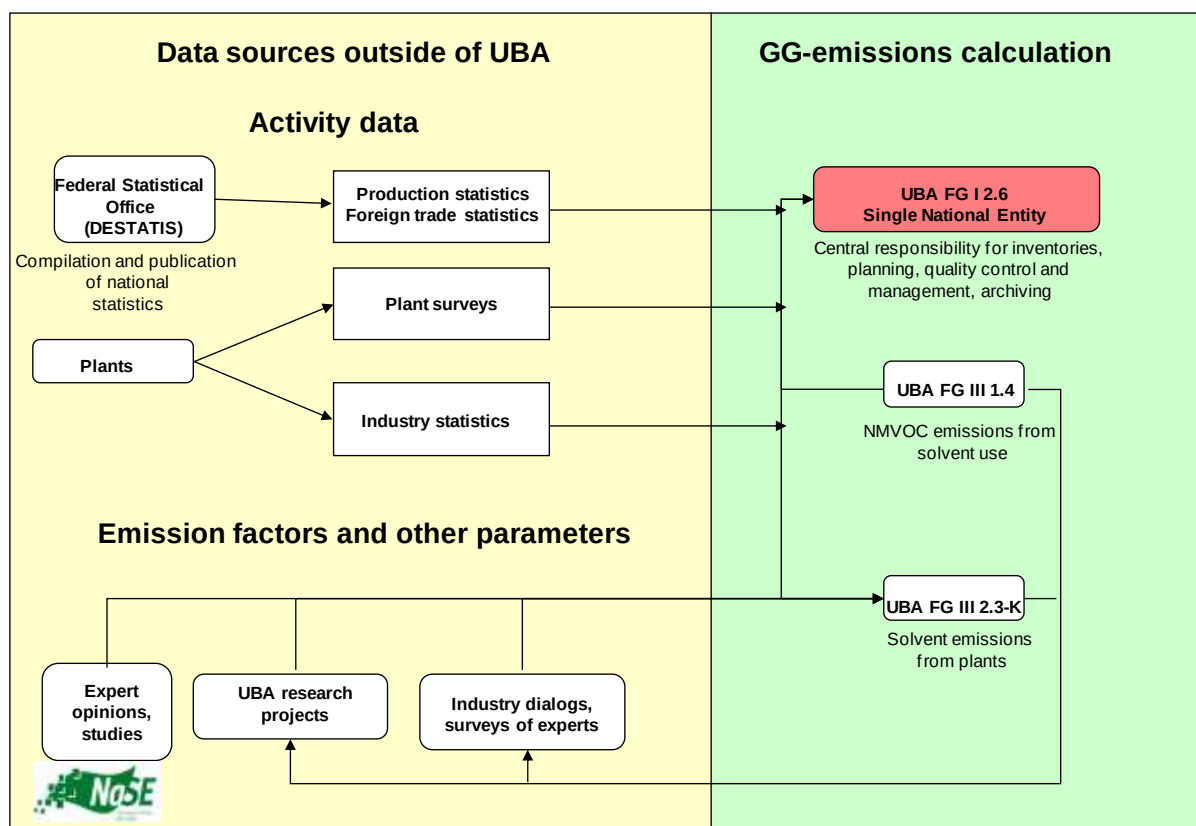


Figure 12: Responsibilities and data flows for calculation of greenhouse-gas emissions from use of solvents and other products

The Federal Environment Agency's Section (FG) III 1.4 *Substance-related Product Issues* is responsible for calculating NMVOC emissions from the area of solvent and other product use. With regard to the sub - source category of solvent emissions from plants, the Federal Environment Agency's Section III 1.4 *Substance-related Product Issues* is supported by the agency's Section (FG) III 2.3 *Chemical Industry, Energy Production* in the framework of the latter section's "global responsibility". The Federal Environment Agency has not yet specified internal responsibilities for determining N₂O emissions from products.

Activity data are drawn mainly from published statistics of the Federal Statistical Office, especially from its statistics on production and foreign trade. The activity data are supplemented with industry statistics and information supplied by experts. For N₂O emissions, research-project results and companies' figures are used.

Emission factors, along with other parameters that enter into calculation of emissions from solvent and other product use, are taken from national studies, experts' opinions and research projects directly commissioned by the Federal Environment Agency; in some cases, they are also based on information provided by experts in the context of dialogs with industry.

1.4.1.1.4 Agriculture

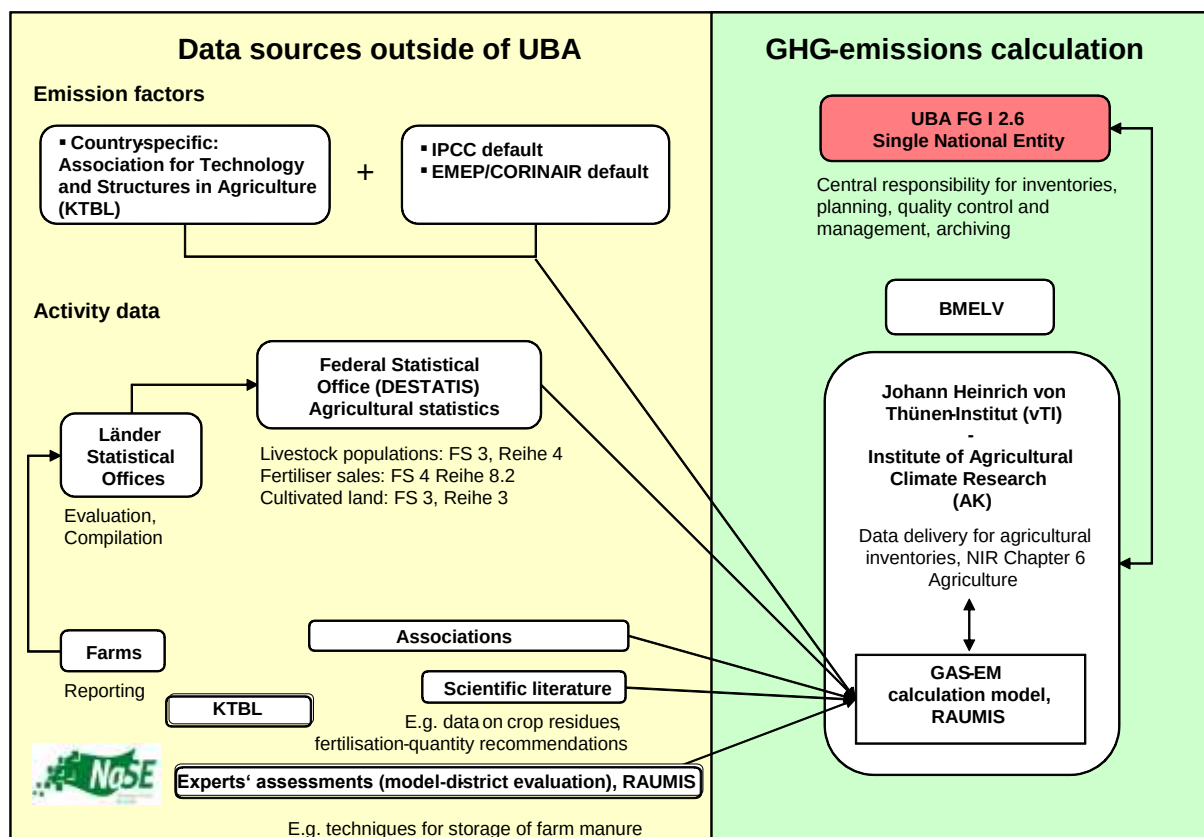


Figure 13: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture

Emissions calculations for source category 4 (Agriculture) are carried out by the von Thünen Institute (vTI). For calculation of agricultural emissions in Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) initiated a suitable joint project, in the framework of which the former Federal Agricultural Research Institute (FAL) developed a modular model for relevant spread-sheet calculation (GASeous Emissions, GAS-EM) (Dämmgen et al, 2002 & 2009a). The BMU and BMELV now have a framework ministerial agreement in place for management of relevant data and information exchange and for operation of a joint database at the UBA and the FAL.

Agricultural statistics of the Federal Statistical Office are another important data source for calculation of agricultural emissions. Animal statistics have been taken from *Fachserie 3, Reihe 4* of the Federal Statistical Office (*FEDERAL STATISTICAL OFFICE, Fachserie 3 Reihe 4*); other *Fachserien* (technical series) provide data on amounts of fertiliser sold and agricultural land under cultivation. In some areas, such data are supplemented by figures from the pertinent literature (for example, crop residues and recommended fertiliser quantities). Additional data are available from experts' assessments (for example, an evaluation of model districts with regard to techniques for storing farm fertilisers).

In many areas, calculations for the agriculture sector are based on highly differentiated activity data obtained via national data sources. Also in many areas, such data are combined with the standard emission factors given in the 1996b and 2006 IPCC Guidelines or the EMEP/EEA manual of the United Nations Economic Commission for Europe (UN ECE).

1.4.1.1.5 Land-use changes and forestry

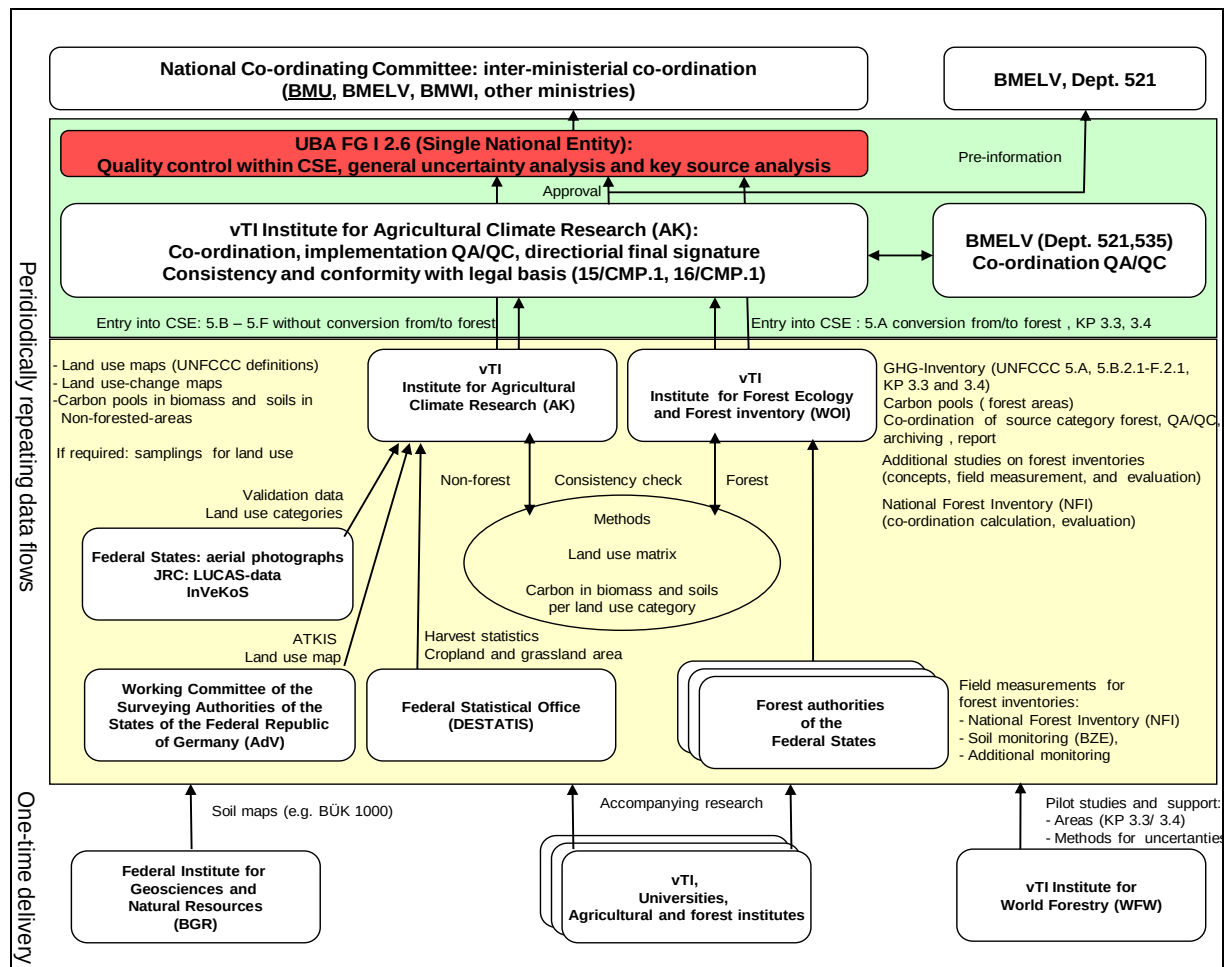


Figure 14: Data flows for calculation of greenhouse-gas emissions from the areas of land-use changes and forestry (LULUCF) and KP-LULUCF

The changes in carbon stocks in forest biomass, and the activity data for forest and land-use changes (uses changed to and from forest), were derived for the first time for the 1990-2003 greenhouse-gas inventory. In that work, carried out on behalf of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) by the Forest Research Institute Baden-Württemberg (Forstliche Versuchs- und Forschungsanstalt; FVA) and, as of 2004, by the Johann Heinrich von Thünen Institute (vTI), the changes were derived primarily from the data of National Forest Inventories (Bundeswaldinventuren; BWI) and the Datenspeicher Waldfonds (DSWF) database, in keeping with provisions of the Good Practice Guidance Land-Use, Land-use Change and Forestry (GPG-LULUCF, IPCC, 2003). Details relative to data sources are provided in Chapter 7.2.1. CO₂ emissions were determined via the stock-change method. The activity data are based on data of the National Forest Inventories, as well as on information from the project GSE Forest Monitoring – Inputs for National Greenhouse-gas Reporting (GSE FM-INT). When the results of the next National Forest Inventory (Bundeswaldinventur 3) become available, in 2012, another recalculation will be carried out for the period 2003 to 2012. That recalculation is expected to provide finalised emissions estimates. Recalculation will then also be carried out with regard to activity data for the same period, thereby increasing quality. In addition, expanded uncertainties estimates will be available. A nation-wide inventory study 2008 (Inventurstudie 2008; IS08) on data collection for the 2008 commencement of the 2008-2012 commitment period has enhanced

conclusions regarding trends during that commitment period. CO₂ emissions from forests have been redetermined for the period 2002 to 2008.

Reporting on forestry activities pursuant to Article 3 (4) of the Kyoto Protocol will thus be based primarily on statistical and spatial surveys using a systematic sampling raster. Samples will be taken at the raster's nodes (cf. Chapter 11). Forests' function as carbon sinks, in terms of carbon stored in biomass, can be estimated for the period between 2002 and 2012 on the basis of the National Forest Inventory 2 (Bundeswaldinventur 2), the inventory study 2008 (IS08) and the National Forest Inventory 3 (Bundeswaldinventur 3; sample year 2012), which is currently in preparation.

Area surveys for determination of use changes in the areas of cropland, grassland, wetlands, settlements and other land are carried out with the help of a digital landscape model (B-DLM/ATKIS). That model divides the Federal Republic of Germany into defined areas, all of which are fully georeferenced. "Wall-to-wall" use of unique identification numbers for the areas eliminates the possibility of any double-counting. The system is continually updated by the surveying authorities of the Länder and the Federal Agency for Cartography and Geodesy (BKG). For purposes of the inventory, land-use changes are determined on an annual basis, with the help of a GIS.

Soil carbon stocks are estimated with the help of soil maps provided by the Federal Institute for Geosciences and Natural Resources (BGR), while use-related changes in these stocks are estimated using emission factors derived from the scientific literature.

Changes in biomass carbon stocks are estimated on the basis of harvest statistics, the main survey on soil use (Bodennutzungshaupterhebung) and specific factors given in the pertinent scientific literature (and used in conjunction with data from the digital landscape model). Emissions from liming of soils are determined with the help of data, taken from Federal fertiliser statistics, on domestic sales of mineral fertilisers that contain lime and other nutrients. The fertiliser industry is legally required to disclose its sales.

Projects are underway for improving activity data and, especially, for determining country-specific emission factors for carbon and nitrogen – and CO₂, CH₄ and N₂O (such as the "Organic Soils" project and the Soil-condition Survey for the Agriculture Sector project ("Bodenzustandserhebung Landwirtschaft"), both of which have been underway since 2009, etc.). These projects will lead to high-quality estimates of emissions and removals for the land-use categories forest, cropland, grassland, wetlands, settlements and other land uses, as well as to considerable reductions in uncertainties.

As a result of inconsistencies in area designations, and in the relevant time series, the LULUC reporting system will be converted completely to raster-based sampling method over the next two years. For the present submission, a mixed approach was used, as an interim solution designed to prevent inconsistencies. For this purpose, the results of the forestry sampling inventory were synthesised with those of the georeferenced approach, for all non-forest areas. In addition, as a result of the inconsistencies in the time series, inconsistencies caused by use of different data sources (1990 – 2000 CORINE (UBA), 2000 – 2009 ATKIS® (AdV)), land use and land-use changes for the years 1990 – 2000 were again reconstructed, via back-extrapolation of ATKIS® data.

1.4.1.1.6 Waste and wastewater

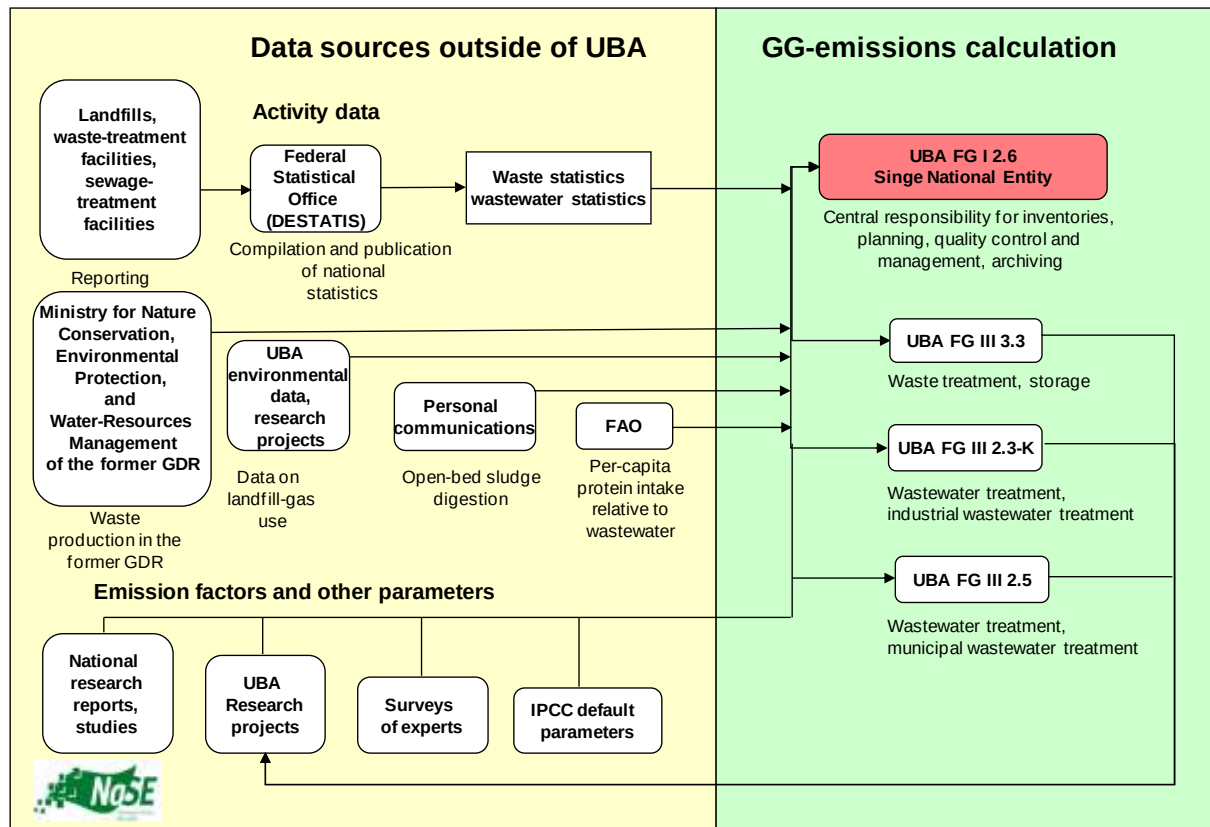


Figure 15: Data flows for calculation of greenhouse-gas emissions from the area of waste and wastewater

Federal Environment Agency Section FG III 3.3 *Waste treatment, waste storage* is responsible for selecting the methods, parameters and data for calculating emissions from the waste sector. In recalculation of landfill emissions in 2003 (development of the Tier 2 method for the Federal Republic of Germany), and in refinement of the Tier 2 method in 2006, the Federal Environment Agency was supported by a research project (ÖKO-INSTITUT, 2004b).

Activity data in the waste sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on waste provides precise information as to what statistical series and sources were used. The Federal Statistical Office has not published any data on amounts of waste produced in the former GDR. In this area, an official source of the former GDR's ministry for nature conservation, environmental protection and water-resources management was used. The calculations relative to landfill-gas use are based on data from the Energy Balances and from Fachserie 19 of the Federal Statistical Office.

The emission factors and other parameters that enter into calculation of emissions from waste landfilling, from mechanical-biological waste treatment and from composting were taken from national studies and research reports conducted/prepared in research projects commissioned directly by the Federal Environment Agency. IPCC default parameters were also used for this purpose. Selected experts were also consulted regarding a few of the relevant parameters (for example, half-life selection). The relevant chapter presents the sources for the various parameters, in detail.

The Federal Environment Agency's Section III 2.3K *Chemical Industry, Energy Production* is responsible for selecting the methods, parameters and data for calculating emissions from the industrial wastewater / sewage sludge handling sector (6.B.1). The Federal Environment Agency's Section III 2.5 *Monitoring Methods, Waste Water Management* is responsible for selecting the methods, parameters and data for calculating emissions from the municipal wastewater handling sector (wastewater and sewage sludge) (6.B.2).

Activity data in the wastewater sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on wastewater provides precise information as to what technical series and sources were used. The data on per-capita protein intake are taken from FAO data.

The emission factors and other parameters that enter into calculation of emissions from wastewater treatment were taken from national studies and research projects commissioned directly by the Federal Environment Agency. IPCC default parameters are also used. Various experts were consulted directly regarding a few parameters and methodological issues (for example, production of CH₄ emissions in aerobic wastewater-treatment processes).

1.4.1.2 Methods

The methods used for the individual source categories are outlined in the overview tables for the various source categories and in summary tables 3s1 and 3s2 of the CRF reporting tables. A distinction is made between calculations made with country-specific ("cs") methods and calculations made, in the various source categories, with IPCC calculation methods of varying degrees of detail (of varying "Tiers")¹⁴. The manner in which a calculation is assigned to the various IPCC methods depends on the pertinent source category's share (expressed as equivalent emissions) of total emissions. Such assignment is carried out via an instrument known as "key-source analysis" (cf. Chapter 1.5 in this regard).

In the present report, emissions from air transports are calculated, for the first time, completely in accordance with the IPCC's Tier 3 method, i.e. separately national and international transports, and using specific emission factors for the different flight phases and aircraft classes involved. Further information regarding the procedure used is presented in Chapters 3.2.2.2 and 3.2.10.1.

Greenhouse-gas emissions from road transports are calculated with the help of the TREMOD model, which is based on a bottom-up Tier-2/3 approach. In that model, fuel consumption figures, checked against the Energy Balance, are distributed among individual vehicle and road categories. The relevant emissions are calculated within the CSE database, on the same level of detail, following transfer of those specific consumption data, and of corresponding emission factors. Further information regarding this procedure is provided in Chapters 3.2.10.2 and 19.1.3.2 of this inventory report.

In the area of industrial processes, chemical-industry emissions of source categories 2.B.1 through 2.B.4 are calculated in accordance with the IPCC Tier 3 method. Emissions of source category 2.B.5 are calculated via country-specific and IPCC-Tier-2 methods. Detailed IPCC tiers are also used in many areas relative to the greenhouse gases HFCs, PFCs and SF₆. This is possible, in particular, because emissions for these greenhouse gases have been surveyed specifically for emissions reporting, within the context of an R&D project, and

¹⁴ *Tier 1* refers to the simpler calculation methods that may be used with fewer input data, whereas *Tier 2* and *Tier 3* require more differentiated input data and hence generally lead to more accurate results.

the relevant data have been collated specifically with a view to application of the IPCC methods.

NMVOC emissions from solvent use, converted into indirect CO₂, are calculated on the basis of a product-consumption approach pursuant to the IPCC Guidelines 1996.

For agriculture, emissions were calculated primarily on the basis of the CORINAIR Guidebook, using IPCC default emission factors. Calculations for key categories were carried out using an IPCC-Tier 2 procedure, with country-specific emission factors. Country-specific methods were applied only for agricultural soils (4.D).

Calculation for the waste sector was modified in line with the IPCC Tier 2 approach, and relevant new national data sources were developed (ÖKO-INSTITUT, 2004a).

All other source categories were listed in the IPCC Summary Tables as having country-specific calculation methods. In this respect, it should be noted that the German inventories are currently being subjected to an intensive review process in which compliance of the applied methods with the IPCC approach is being systematically reviewed for the first time, and methodological changes are being implemented in order to conform to the *Good Practice Guidance*. As this methodological review is not yet complete, certain methods in the Summary Tables have been listed as country-specific even if it is not yet known whether IPCC conformity exists or which Tier has been used. However, in the case of energy-related activity data, it can be assumed that Tier 1 has been used as a minimum. For other areas, too, classification will change from "country-specific" to IPCC Tiers, since methodological conformity will either be confirmed or achieved during the course of the year.

1.4.2 KP LULUCF activities

The data sources and methods used for KP reporting do not differ from the data sources and methods used for reporting for source category 5.A in the UNFCCC framework. There are thus no differences with regard to the present purpose. Cf. also Chapter 1.4.1.1.5, Chapter 7.2 and Annex Chapter 19.5.1.

1.5 Brief description of key categories

1.5.1 Greenhouse-gas inventory (with and without LULUCF)

The key categories were defined by applying two Tier 1 procedures, Level (for the base year, for 1990 and for 2009) and Trend (for 2009, as compared to the base year), to German greenhouse-gas emissions. In addition, the Tier 2 method was used. In keeping with the pertinent IPCC specifications for the Tier 1 method, analysis focussed both on emissions from sources and on storage of greenhouse gases in sinks. The analyses are first carried out solely for emissions from the sources listed in Annex 1 of the UN Framework Convention on Climate Change and, then, in a second step, for storage of greenhouse gases in sinks. All specified key categories result from work in 2009 – they resulted either from level analysis for 2009 or from trend assessment.

For 2009, the Tier 1 approach identified 39 source categories, out of a total of 120 source and sink categories studied, as key categories. Only 26 of these were identified, by both trend and level analysis, as key categories. In addition, 8 source categories were identified as key categories solely by trend analysis, and 5 source categories were so identified solely

by level analysis. Via the Tier 2 approach, 7 additional key categories were identified (cf. Table 8).

Ultimately, 46 key categories were defined. These are summarised in Table 8.

Table 5: Number of source categories and key categories

Source categories			120
			Key categories
by Level 5	Level & Trend 26	Trend 8	39 (Tier 1) +7 (Tier 2) 46 (total)

Table 7 provides an overview of the results of Tier-1 key-category analysis. Table 8 shows the additional key categories identified via Tier 2 analysis. Annex 1 (Chapter 17) of this report presents detailed explanations of the key-category analysis carried out.

The Tier-2 key-category analysis has been the main source of changes with respect to last year's results. With regard to analysis based solely on Tier 1, the following source categories have been eliminated in this area: CO₂ emissions from use of diesel fuel in ship transports (1.A.3.d), SF₆ emissions from uses in aluminium and magnesium production (2.C.4) and CO₂ emissions from 5.F Other land are no longer key categories. On the other hand, N₂O emissions from the source category Solvents and other product use (3.D) are a key category.

1.5.2 Inventory with KP-LULUCF reporting

As a result of the analysis, as described in the previous chapter, of the UNFCCC inventory, CO₂ emissions/storage in the categories *Forest Land* (5.A), *Cropland* (5.B) and *Grassland* proved to be key categories. For these categories, additional detailed analyses were carried out, in line with the methodological specifications set forth in chapter "5.4 methodological choice – identification of key categories" of the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003). As a result, the sub-categories listed in Table 6 were identified as key categories for the KP-LULUCF inventory pursuant to Article 3.3. The key factors in such selections were the relevant emissions-contribution levels and emissions trends. With the help of Table 5.4.4, the activities selected in accordance with Article 3.4 were then correlated with these categories. Under this article of the Kyoto Protocol, Germany has selected only the category "forest management". These results, as well as the criteria used for the selection, are presented in CRF Table NIR.3 (Table 279 in Chapter 17.1.3).

Table 6: Results of KP-LULUCF key-category assessment

IPCC Source categories	Emissions / Sinks of	1990	2009	Key category assessment
5.A.1 Forest Land remaining Forest Land	CO₂	-70987.6	-20642.4	●
5.A.1 Forest Land remaining Forest Land	CH ₄	0.4	0.2	
5.A.1 Forest Land remaining Forest Land	N ₂ O	0.1	0.1	
5.A.2 Land converted to Forest Land	CO₂	934.2	-4779.2	●
CHALK CROPLAND	CO ₂	1158.9	1683.0	
5.B.1 Cropland remaining Cropland	CO₂	21565.2	22998.5	●
5.B.1 Cropland remaining Cropland	N ₂ O	0.0	0.0	
5.B.2 Land converted to Cropland	CO ₂	5915.0	2422.5	
5.B.2 Land converted to Cropland	N ₂ O	2.3	1.1	
5.C.1 Grassland remaining Grassland	CO₂	10132.5	12356.5	●
5.C.2 Land converted to Grassland	CO ₂	-5433.4	-1635.6	
5.D.1 Wetlands remaining Wetlands	CO ₂	2236.1	2355.8	
5.D.2 Land converted to Wetlands	CO ₂	-72.3	52.5	
5.E.1 Settlements remaining Settlements	CO ₂	1938.6	1883.6	
5.E.2 Land converted to Settlements	CO ₂	546.8	395.0	
5.F.1 Other Land remaining Other Land	CO ₂	0.0	0.0	
5.F.2 Land converted to Other Land	CO ₂	0.0	0.0	
5.G Other	CO ₂	116.8	65.4	

Table 7: Key categories for Germany pursuant to the Tier 1 method

IPCC Source Categories	Activity	Emissions of	Level						Trend		Emission Base Year	Emission 2009
			Base Year	Base Year +sinks	LEVEL 1990	1990 +sinks	LEVEL 2009	2009 +sinks	2009	2009 +sinks		
1A1a Public electricity and Heat production	all fuels	CH4							•	•	185.8	1,567.8
1A1a Public electricity and Heat production	all fuels	CO2	•	•	•	•	•	•	•	•	339,017.9	305,235.0
1A1a Public electricity and Heat production	all fuels	N2O						•			3,610.0	3,371.1
1A1b Petroleum Refining	all fuels	CO2	•	•	•	•	•	•	•	•	20,005.9	20,270.2
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO2	•	•	•	•	•	•	•	•	64,393.8	13,029.9
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	CO2	•	•	•	•	•	•			15,581.8	11,564.4
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	CO2							•	•	1,989.2	162.9
1A2f Manufacturing Industries and Construction: Other	all fuels	CO2	•	•	•	•	•	•	•	•	156,458.9	88,571.2
1A3b Transport: Road Transportation	all fuels	CO2	•	•	•	•	•	•	•	•	150,358.3	144,615.5
1A3c Transport: Railways	all fuels	CO2							•	•	2,880.8	1,126.7
1A3e Transport: Other Transportation	all fuels	CO2	•	•	•	•	•	•			4,302.3	3,607.6
1A4a Other Sectors: Commercial/Institutional	all fuels	CH4							•		1,216.1	56.5
1A4a Other Sectors: Commercial/Institutional	all fuels	CO2	•	•	•	•	•	•	•	•	63,949.6	37,579.4
1A4b Other Sectors: Residential	all fuels	CO2	•	•	•	•	•	•	•	•	129,474.0	102,420.9
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	CO2	•	•	•	•	•	•	•	•	11,059.8	6,051.8
1A5 Other: Include Military fuel use under this category	all fuels	CO2	•	•	•	•			•	•	11,811.1	1,339.1
1B1a Fugitive Emissions from Fuels: Coal Mining and Handling	Solid Fuels	CH4	•	•	•	•			•	•	18,415.2	2,763.9
1B1c Fugitive Emissions from Fuels: Other (Abandoned Mines)	Solid Fuels	CH4							•	•	1,806.8	75.3
1B2b Fugitive Emissions from Fuels: Natural Gas	Gaseous Fuels	CH4	•	•	•	•	•	•	•	•	6,782.3	6,912.7
2A1 Mineral Products: Cement Production	Clinker Production	CO2	•	•	•	•	•	•	•	•	15,145.8	12,312.8
2A2 Mineral Products: Lime Production	Limestone and Dolomite	CO2	•	•	•	•	•	•			6,176.5	4,539.5
2B1 Chemical Industry	Ammonia Production	CO2	•	•	•	•	•	•	•	•	5,745.0	6,845.0
2B3 Chemical Industry	Adipic Acid Production	N2O	•	•	•	•	•	•	•	•	18,804.6	8,570.0
2B5 Chemical Industry	Other	CO2	•	•	•	•	•	•	•	•	6,888.2	8,749.6
2C1 Metal Production: Iron and Steel Production	Steel (integrated production)	CO2	•	•	•	•	•	•	•	•	22,711.9	11,669.5
2C3 Aluminium Production		PFC's							•	•	1,551.7	247.2
2E Production of Halocarbons and SF6		HFC's	•	•	•	•			•	•	4,218.5	745.7
2F Industrial Processes	Consumption of Halocarbons and SF6	HFC's					•	•	•	•	C	C

IPCC Source Categories	Activity	Emissions of	Level						Trend		Emission Base Year	Emission 2009
			Base Year	Base Year +sinks	LEVEL 1990	1990 +sinks	LEVEL 2009	2009 +sinks	2009	2009 +sinks		
2F Industrial Processes	Consumption of Halocarbons and SF6	SF6	•	•	•	•			•	•	C	C
3D Total Solvent and Other Product Use		N2O							•	•	1,924.6	314.6
4A1 Enteric Fermentation	Dairy Cattle	CH4	•	•	•	•	•	•	•	•	14,135.1	11,326.3
4A1 Enteric Fermentation	Non-Dairy Cattle	CH4	•	•	•	•	•	•			11,827.2	8,435.0
4D1 Agricultural Soils	Direct Soil Emissions	N2O	•	•	•	•	•	•	•	•	30,785.2	27,167.6
4D1 Agricultural Soils	Indirect Emissions	N2O	•	•	•	•	•	•	•	•	17,194.6	14,745.2
5A Forest Land		CO2		•		•		•		•	-70,053.4	-25,421.6
5B Cropland		CO2		•		•		•		•	28,639.1	27,103.9
5C Grassland		CO2		•		•		•		•	4,699.1	10,720.8
6A Solid Waste Disposal on Land	Managed Waste Disposal on Land	CH4	•	•	•	•	•	•	•	•	38,598.0	8,463.0
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4							•	•	2,226.2	80.9

Table 8: Key categories for Germany identified solely via the Tier 2 approach

IPCC Source Categories	Activity	Emissions of
1B2b Fugitive Emissions from Fuels: Natural Gas	Gaseous Fuels	CO ₂
4B1 Manure Management	Dairy Cattle	CH ₄
4B1a Manure Management: Other	Dairy Cattle	N ₂ O
4B8 Manure Management: Swine	Swine	CH ₄
5D Wetlands		CO ₂
5E Settlements		CO ₂
6B Wastewater Handling	Domestic and Commercial Wastewater	N ₂ O

1.6 Information regarding the quality assurance and quality control plan, the inventory plan (including verification) and management of confidential information

As of the 2006 report, inventories are submitted using the CRF-Reporter software provided by the climate secretariat. Like previous versions, the current version contains a range of programming errors. The identified programming errors have been communicated to the UNFCCC. As a result of existing software errors, data-validity problems cannot be ruled out. In addition, the time and care required to carry out quality assurance for data entry exceed the relevant limits in light of the applicable deadlines. The German QSE cannot solve this problem with measures of its own; the FCCC Secretariat is requested to correct this situation.

1.6.1 *Quality assurance and quality control procedures*

1.6.1.1 QC/QA plan

Pursuant to the IPCC Good Practice Guidance requirements, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and assuring the proper execution of such QC/QA measures.

Organisation:

A general description of the manner in which the quality assurance and control process is organised – with regard to both establishment and workflow – is provided in Chapter 1.3.3.1. That section also describes the principles by which QC/QA measures are controlled, as well as the sorts of documents and records kept in the process.

Planning:

The requirements for quality assurance and quality control measures in emissions reporting are described in detail in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 280/2004/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG" (Federal Environment Agency, 2007b, unpublished). The most important specifications set forth in the handbook consist of quality reviews carried out primarily during inventory preparation.

Execution:

The quality checks are carried out with the help of checklists (for the relevant content, cf. Chapters 1.3.3.1.4 and 22.1.2.1.11). These lists currently comprise some 100 role-specific individual targets and some 50 optional targets.

Currently, some 50 Federal Environment Agency and external staff, in various functional roles, and in four layered, cumulative QC/QA review levels, are involved in emissions reporting. The review levels are represented, in each case, by the relevant expert (Fachverantwortlicher - FV), his superior, the quality control manager (Qualitätskontrollverantwortlicher - QKV), a specialised contact person, within the Single National Entity, for the relevant source category (Fachlicher Ansprechpartner - FAP) and,

finally, the co-ordinators responsible for achieving a consistent overall result comprising the NIR, the inventory, the QSE and uncertainties estimates.

In inventory preparation, role-specific QC/QA reviews are linked with general quality targets (cf. Chapter 22.1.2.1.10.3)) and individual process steps (cf. Chapter 1.2.3), so that final evaluation can take account of such targets and steps. As a whole, the reviews cover the entire inventory-preparation process.

Subsequent evaluation of the checklists identifies source categories that need to be reviewed – and, possibly, revised – with regard to fulfillment of specific inventory requirements. Such fulfillment is achieved via addition of pertinent further information. The great majority of all identified review requirements are added to the binding inventory plan. The inventory plan undergoes internal and interdepartmental approval processes and is then published in aggregated form.

1.6.1.2 Inventory plan

For preparation of the inventory plan, the QC/QA checklist results for all source categories are evaluated. Those results are combined with any results of improvement activities mentioned in the NIR (cf. Chapter 10.4.1) and with evaluations of results of the various review procedures of the UNFCCC and the EU Commission. The inventory plan comprises a range of individual measures that are to be implemented by the various roles within the QSE (FV, QKV, FAP, ZSEK, QSEK and NaSEK; cf. the role concept within QSE, Chapter 1.3.3.1.2) and by the Federal German ministries involved in emissions reporting (cf. Chapter 1.2.1.4). In the interest of clarity, the measures as shown in the table are not grouped in accordance with pertinent areas of responsibility (such as federal ministries, the Federal Environment Agency or the roles FV, QKV, FAP, NaSEK, etc), with emissions parameters (AR, EF, emissions, etc.) or with sources of individual measures. The relevant individual measures have been combined to yield the overarching measures shown in Table 9. The inventory plan is regularly updated, within an ongoing process.

Regularly, as inventory-plan measures are implemented, large numbers of the included individual measures are processed to the point where they can be removed from the list.

Table 9: Inventory plan 2010

Planning for inventory improvement / required actions	Category (CRF code)
Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled.	6.B.2
Check whether the data source (s) used will be available throughout the long term.	1.A.2
Check whether there are any gaps in the available data for time series as of 1990.	2.C.2+3, 4.A.(b), 4.B.(b), 4.D
Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.	1.A.3.e.ii, 6.B.2
Check whether uncertainties have been determined and are complete.	1.A.2, 1.A.3.a.ii+c+e.ii, 1.A.5.b, 2.C.1-3, 5.B-D, 6.A.1, 6.B.2
Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete and meaningful.	1.A.2.f, 1.A.3.a.ii, 1.A.3.b+c+d.ii+e.ii, 1.A.4.c.ii, 1.A.5.b, 1.B.1+2, 1.C.1.b, 2.C.1, 2.D.1, 6.B.2
Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.	1.A.2+3, 1.A.4.c.ii, 1.A.5.b, 1.C.1.b, 2.C.2, 4.A.(b), 4.B.(b), 4.D, 6.B.2
Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	1.A, 1.A.1+2, 1.A.2.a+f, 1.A.3.a.ii+b+c+d.ii+e, 1.A.4.c.ii, 1.A.5.b, 1.B.1+2, 2.A.1+2+4, 2.B.1, 2.C.1+3, 2.D.2, 6.A.1, 6.B.2
Check whether it was possible to take pointers from inventory reviews into account.	1, 1.A.1.a, 1.A.2.a, 1.A.3.b, 2.C.3, 5, 5.A.1, 6, 6.A.1, 6.B.2, 6.C
Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	1.A.2.+a, 1.A.4.c.ii, 2.D.1.(b), 6.B.2
Check whether the EF are plausible and complete (have no gaps and are completely documented).	1.A.3.e.ii, 5.B, 5.C, 5.D
Check whether the AR are plausible and complete (have no gaps and are completely documented).	1.A.1.a, 1.A.3.a, 2.A.7.(a), 4.A.(b), 4.B, 4.D, 5.A, 6.A.1, 6.D.2
Check whether data has been entered into the CSE correctly, including whether all numbers, units and conversion factors have been correctly entered and properly integrated.	6.B.2
Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	1.A.2.f.(a+c), 2.D.1.(b), 6.B.2
Various types of required action.	1.A.3.a+d+e, 1.A.4, 1.B.2.d, 2.A.5, 2.C.1, 2.D.1, 4, 4.A+B+D, 5
Check whether pertinent responsibilities need to be updated.	1.B.1, 2.A.5+6, 2.B.5.(e), 3.D.1+4
Initiated research projects for inventory improvement.	1.A.1, 1.A.2.f, 1.A.3.e, 1.B.1.c, 1.B.2, 1.C.1.B, 2.A.2, 2.A.6, 5.A.+D+E, 6.A.1, 6.D.1

1.6.2 Activities for verification

1.6.2.1 Procedure for using monitoring data from European emissions trading

In efforts to fulfil mandatory quality criteria, a need has been seen – especially within the EU – to use data from the EU Emissions Trading Scheme (EU ETS) to improve greenhouse-gas emissions inventories. All Member States are now called upon to use ETS data to improve the quality of their annual national emissions inventories.

A reliable database from emissions trading, showing relevant annual emissions, is available for the period since ETS monitoring commenced. This data can be used, in aggregated form, to draw source-category-specific conclusions regarding the completeness and consistency of certain parts of emissions inventories. In addition, it provides a basis for reviewing emission factors used and for verifying activity data. Since emissions calculations for all components are all based on the same activity data, such verification is of significance for all reported emissions inventories.

Emissions-trading data required for improvement of inventory data subject to reporting are available in electronic form, in the installations database of the German Emissions Trading Authority (DEHSt). In 2005, agreement was reached regarding a general procedure for

individual data queries related to inventory preparation. In the main, this procedure involves direct communication between the Single National Entity and the German Emissions Trading Authority's section E 2.3.

Monitoring data from the European Emissions Trading Scheme (ETS) will be used to improve the quality of annual national emissions inventories with respect to source categories that include installations subject to reporting obligations under the ETS CO₂ Emissions Trading Scheme.

In a research project (ÖKO-INSTITUT, 2006b), allocation rules were developed that make it possible to compare data from verified emissions reports with data from the inventories' database, on a year-by-year basis. The comparisons, which have been carried out only once to date, have confirmed, in principle, the usefulness of such comparisons for verifying individual source categories and identifying data gaps. To make it possible to use this "resource" on a regular basis, a formalised procedure for the pertinent required annual data exchanges, including deadlines and defined workflows, has been agreed.

1.6.2.2 Workshop on the National System (Peer Review)

In November 2004, the Federal Environment Agency held a first workshop on the National System of Emissions Inventories. This created a forum that significantly promoted inclusion of associations and other independent organisations, as well as supporting implementation of Paragraph 15 (b) of the *Guidelines for National Systems*, which requires that inventories be reviewed by third parties (peer review).

In May 2009, a second workshop on the National System was held, with the purpose of facilitating another review of the inventories by independent third parties, pursuant to Paragraph 15 (b) of the *Guidelines for National Systems*. That second workshop focussed on specific source categories within the inventory. The selected areas included "N₂O from product use", "emissions from non-energy-related use of fossil fuels" and "SF₆ emissions from the photovoltaics industry". The persons invited to the discussion of inventory areas included experts from the various sectors, industry representatives and independent experts. For example, with regard to the area of use of N₂O, the invited participants included sellers of industrial gases, and representatives of the Berufsverband deutscher Anästhesisten (BDA; Professional Association of German Anaesthetists) and of the Federal Institute for Materials Research and Testing (BAM). With regard to the area of non-energy-related uses, discussions were held with representatives of the Association of the German Chemical Industry (VCI) and of affected chemical producers. Participants with a focus on photovoltaics production included representatives of producers, industrial-gas sellers, systems builders, universities and research establishments. The topics were comprehensively and intensively discussed. The workshop contributed significantly to overall improvement of the data and of the quality of reporting. For 2011, a further workshop on the source categories of agriculture and LULUCF is planned. With that workshop, Germany is following the recommendation made in Art. 39 of the Initial Review 2007.

1.6.3 Handling of confidential information

When the Federal Statistical Office began providing data in connection with the entry into force of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), the Federal Environment Agency received access to data subject to statistical secrecy.

In addition, from associations and companies, the Single National Entity receives activity rates, emission factors and emissions data that reflect operational and business secrets and that are otherwise confidential.

In storing and using such data, therefore, the Single National Entity must take special precautions, and apply special procedures, to protect the confidentiality of the data.

In particular, it must provide for strict separation (both spatial and in terms of staff assignments) of statistical work / analysis and any enforcement of legal provisions pertaining to the installations for which data are collected.

The Single National Entity has taken a range of measures to fulfil these requirements. For example, as a basic rule, persons charged with enforcement of laws in a specific area are never permitted to carry out specialised tasks relative to emissions reporting in the same area.

In 2008, the Single National Entity commissioned a legal study with the aim of precisely assessing the requirements and possibilities pertaining to use and management of data for emissions reporting. The results are currently being used for revision and refinement of the Single National Entity's concept for handling confidential data.

Previously, access to the Central System on Emissions (CSE) database was already limited to a specified group of authorised persons. That measure represents the key precaution for dealing with confidential data. In particular, it makes it practicable to separate - in terms of the persons involved - the tasks of data analysis and legal control. In addition, in 2009 a special access-restricted area was set up, on a central server of the Federal Environment Agency, for confidential electronic data that are not centrally stored in the CSE (for example, emissions-control declarations, data relative to large combustion plants, information about production processes, etc.).

Furthermore, data provided by the *Federal Statistical Office* are placed on a password-/access- protected server (i.e. available only for specifically authorised persons) at the *Federal Statistical Office*.

1.7 General estimation of uncertainties

1.7.1 Greenhouse-gas inventory

The IPCC Good Practice Guidance (GPG, 2000) characterises determination of uncertainties as a key element of any complete inventory. As a result of the GPG's focus on continual inventory improvement, uncertainties in the inventories play an important role. Uncertainties information is used primarily as an aid for improving the precision of inventories, as well as for selecting methods and carrying out recalculations for inventories. The declared aim is to minimise uncertainties to the greatest possible degree, in order to maximise the inventories' accuracy. Annex I countries must thus first quantify the uncertainties for all source categories and sinks, in order to enhance their assessment of inventory quality – which assessment, in turn, is the key to effective inventory planning.

Uncertainties are quantified for emission factors and activity data; in some cases, they are also quantified for emissions.

In general, two methods for determining uncertainties are differentiated. The Tier -1 method combines, in a simple way, the uncertainties in activity rates and emission factors, for each

source category and greenhouse gas, and then aggregates these uncertainties, for all source categories and greenhouse-gas components, to obtain the total uncertainty for the inventory. The Tier 2 method for uncertainties determination is the same, in principle, but it also considers the distribution function for uncertainties and carries out aggregation using Monte Carlo simulation. In the Tier 2 method, this process also necessarily includes determining a probability density function for both parameters. Ideally, these functions can be determined via statistical evaluation of individual data items (such as measurements for a large number of facilities). In many cases, few relevant values are available, however, and thus the uncertainty must be determined on the basis of experts' assessments.

Research project 202 42 266 (UBA, 2004) determined uncertainties in keeping with the Tier 1 and Tier 2 methods, pursuant to Chapter 6 of the GPG. Since then, the resulting database has been continually improved, and the uncertainties data for the greenhouse-gas inventory have been further improved for the 2009 report. In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. The uncertainties for the activity rates, emission factors and emissions data used were taken from the CSE database. They are based on estimates of experts in relevant departments of the Federal Environment Agency and at external institutions. In cases in which uncertainties information is not yet available in complete form, as an expert's estimate, pertinent figures are added from other sources (such as relevant technical literature), in the framework of a Tier 1 calculation.

1.7.1.1 Procedure for determining uncertainties pursuant to Tier 1

In the Tier 1 method, in keeping with Chapter 6 of the GPG, uncertainties are determined on the basis of the uncertainties for AR, EF and EM, as determined on the lowest sub-category level (primarily by responsible experts of the Federal Environment Agency), and as listed in the CSE. Where asymmetric uncertainties figures are yielded, the larger of the two relevant values is used, under the assumption of a normal distribution, as both the upper boundary and the lower boundary. In each sector, the uncertainties for the various pertinent time series are aggregated, using formula 6.3 of the IPCC Good Practice Guidance (additive combination of uncertainties), to form a total uncertainty for the sector. In the process, the uncertainties for the various activity rates, emission factors and determined emissions (U_i in Formula 6.3) are taken into account, together with the pertinent calculated or otherwise determined emissions (x_i in Formula 6.3). In Formula 6.3, sinks are taken into account as emissions quantities ($|x_i|$ in Formula 6.3). A similar approach applies for determination of the combined uncertainties within the inventory (Column H in Table 6.1 of the IPCC Good Practice Guidance, Formula $G * |D| / \sum |D|$).

1.7.1.2 Results of uncertainties assessment

In general, uncertainties for activity data can be assumed to be smaller than those for emission factors. In particular, the uncertainties are smaller for activity rates derived from fuel use and based on the Federal Energy Balance. On the other hand, uncertainties for activity rates derived from disaggregated fuel use normally increase as the relevant disaggregation increases.

- Pursuant to the results from an R&D project (RENTZ et al, 2002), the uncertainties in emission factors for indirect greenhouse gases in stationary combustion systems (CRF 1.A.1) are relatively small, as a result of regular monitoring of such emissions. Higher uncertainties are listed for N₂O emission factors, since N₂O emissions are not monitored in normal cases. The same applies to the emission factors for CH₄.
- The uncertainties in the Transport source category (primarily CRF 1.A.3) can generally be considered to be small, since precise relevant data on fuel use and vehicle fleets are available, due to taxation obligations, and since that category's emission factors have been very finely modelled and are normally determined via measurements. Some uncertainties may arise via systematic measuring errors or wrong disaggregation.
- In the source category Fugitive emissions from fuels (CRF 1.B), the uncertainties for the activity rates for oil and natural gas (CRF 1.B.2) are low, as a result of the fuels' being subject to taxation. Flaring of natural gas represents the only exception. The activity rates for Coal mining (CRF 1.B.1) are also well-represented by production volumes. The uncertainties for emission factors for fugitive emissions are likely to be higher. On the one hand, this results from the many different technical factors that affect fugitive emissions in transport, storage and processing of oil and natural gas. On the other hand, fugitive CH₄ emissions from coal mining have thus far been taken into account only as lump sums.
- Considerable uncertainties are seen in the area of industrial processes (CRF 2). Activity rates based on production figures that must be reported to the Federal Statistical Office can be subject to uncertainties, especially as a result of discrepancies between reporting structures and relevant industry definitions. Activity rates determined from association information are subject to uncertainties that correlate, in each case, with the degree to which the relevant industrial sector is represented in the association in question. For emission factors, uncertainties – which can be considerable, depending on the greenhouse gas in question – result, understandably, from the factors' strong dependence on technology, in combination with extensive technological diversification. Furthermore, equipment-specific emission factors often are tied to business secrets, particularly in sectors with few market players (for example, manufacturing of chemical products (CRF 2.B)), and this tends to make operators hesitant to publish such data or leads them to provide information in consolidated form. In addition, uncertainties can be higher for complex processes in which non-combustion-related activities generate emissions, if relevant emissions-generating processes are inadequately understood and the relevant contributions of pertinent individual activities are not known.
- In the area of production of alcoholic beverages, within the area of Food and drink production (CRF 2.D.2), the activity-rate uncertainties must be considered very small, since production of such beverages is subject to taxation regulations that require very precise determination of production volumes. On the other hand, statistics for sectors with large numbers of small and medium-sized enterprises (such as baked-goods production) tend to be significantly less precise, and thus the activity rates for such sectors are subject to higher uncertainties. The uncertainties for the relevant emission factors are also larger, due to the sectors' extensive technological diversification.

- The uncertainties for emissions parameters for the source categories Managed waste disposal in landfills (CRF 6.A.1) and Industrial wastewater treatment (CRF 6.B.1) are presumed to be high. This applies especially to the areas of composting, MBT and waste landfilling, which have high waste-type diversity that tends to reduce the reliability of data for the relevant emissions parameters. The activity data are also subject to uncertainties, since the underlying statistical data make use of non-standardised waste and recycling definitions. The general assumptions relative to the uncertainties of activity rates also apply to thermal treatment of waste.

Pursuant to Tier 1, the inventory's total uncertainty figures for 2008 are 6.6 % (level) and 7.1% (trend).

In comparison to the previous year, the total uncertainty has increased, primarily as a result of revision of inventories for nitrous oxide emissions from agricultural soils, inventories which are subject to high levels of uncertainties. At the same time, in some other source categories high default uncertainties were replaced with new expert assessments.

Nitrous oxide emissions overall account for a major share of total uncertainty, and that share is defined noticeably by nitrous oxide from agricultural soils (4.D). Significant contributions to the total uncertainty have also come from the areas of CO₂ sinks and sources of the LULUCF sector and methane emissions from animal husbandry (enteric fermentation, 4.A).

The CO₂ emissions of the sector combustion of fuels (1.A) contribute another important share of the total uncertainty. The predominating components of that share include solid fuels in the sector Public electricity and heat production (1.A.1.a) and mobile sources (1.A.3), especially road transports (1.A.3.b) and combustion in the residential, commercial and institutional sectors (1.A.4.a/b).

Detailed information about the applicable uncertainties is provided in Annex 7 (cf. Chapter 23).

1.7.2 KP LULUCF inventory

Since reporting for source category 5.A under a) UNFCCC and under b) KP does not make use of separate inventories for the two areas, the uncertainties for both reporting areas are the same. The information provided in the previous chapter and in the relevant source category chapters (cf. Chapter 23) applies.

1.8 General review of completeness

1.8.1 Greenhouse-gas inventory

Completeness information for the various individual source categories is presented in CRF Tables 9(a) und 9(b), which, in turn, are summarised in NIR Chapter 21 (Table 314 and Table 315). The following are differentiated in Germany:

- Source-specific emissions and sinks that do not occur (NO – not occurring),
- Source-specific emissions and sinks that are not estimated in Germany, either because they are not quantitatively relevant or because the necessary data for estimates are lacking (NE – not estimated), and
- Source-specific emissions and sinks that are completely accounted for, pursuant to the latest scientific findings, for Germany (All or Full), or that are partly accounted for (Part).

The following section touches on a few source-category-specific approaches for improving the completeness of the inventory.

All combustion-related activities (1 A) from the area of energy are recorded in full. At certain points, the Energy Balance of the Federal Republic of Germany is supplemented if it is evident that complete coverage is not achieved in selected sub-sections (such as the non-commercial use of wood, secondary fuels). In some source categories, separation of combustion-related and non-combustion-related emissions from industry requires further verification. In general, avoidance of duplicate counting is an important part of quality assurance for such categories, however.

In the area of industrial processes, some use is made of production data from association statistics and of manufacturers' information. In the interest of the inventory's completeness and reliability, where emissions reporting is based on such sources, checking of source-category definitions and data-collection methods will continue to receive priority.

The "Not Estimated" (NE) emissions, which are still reported, consist primarily of non-calculated emissions that, pursuant to IPCC GPG (2003, p.1.11), do not have to be calculated by a reporting country, since those emissions are listed in Appendices 3a.2, 3a.3 and 3a.4..

Some of the emissions data available to the Federal Environment Agency are confidential, due to data-protection requirements, and thus are reported only in aggregated form – although they are reported completely.

An agreement covering the DEHSt's provision of data to the Single National Entity has been concluded in order to facilitate regular data exchanges. The regular checking process within the framework of source category responsibility is to be supported by adapting the QC system via checklists.

1.8.2 KP LULUCF inventory

Since reporting for source category 5.A under a) UNFCCC and under b) KP does not make use of separate inventories, the information provided in the previous chapter applies.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

Table 10 below shows the total emissions, as determined for this inventory, of direct and indirect greenhouse gases and of the acid precursor SO₂. The reference figure defined, in keeping with results of review¹⁵ of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol – and independently of any further possible improvements in the basic data – for reduction obligations under the Kyoto Protocol is 1,232,429.543 Gg CO₂ equivalent. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to minus 21 %. Table 11 shows the annual progress achieved, with respect to 1990, for each pertinent year. With the exception of HFCs, significant reductions in emissions have been achieved for all the emissions calculated here. In total, greenhouse-gas emissions, calculated as CO₂ equivalents, decreased by 25.3 % compared to the aforementioned reference figure.

All detailed tables relative to discussion of trends are presented in Annex Chapter 22.3.

¹⁵ "Report of the review of the initial report of Germany", FCCC/IRR/2007/DEU, of 12 December 2007
published at: http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

Trends, taking account of changes with respect to the previous year of the reporting period

In comparison to the previous year, 2008, total emissions decreased enormously, by a full 6.3 %. CO₂ emissions and methane emissions both decreased. Only F-gas emissions increased.

Trend changes resulting from recalculations

Although extensive recalculations were carried out in connection with allocation of CO₂ emissions from the iron and steel sector, the overall trend changed hardly at all.

Table 10: Emissions of direct and indirect greenhouse gases and SO₂ in Germany since 1990

Emissions change (Gg)	1990	1995	2000	2005	2006	2007	2008	2009
Net CO ₂ emissions / storage	1,009,739	897,803	857,842	878,950	883,594	861,491	862,410	805,959
CO ₂ emissions (not including LULUCF)	1,041,688	930,420	890,994	863,955	870,164	847,276	847,967	788,803
CH ₄	107,293	92,198	74,759	57,225	54,172	52,048	51,262	48,799
N ₂ O	87,833	82,617	64,995	64,926	63,804	66,311	67,364	66,897
HFCs (CO ₂ equivalent)	4,369	6,469	6,483	10,001	10,539	11,145	11,474	11,952
HFCs (CO ₂ equivalent)	2,708	1,750	781	709	571	530	531	432
HFCs (CO ₂ equivalent)	4,785	7,220	4,826	3,726	3,651	3,537	3,288	3,223
CO	12,259	6,560	4,894	3,717	3,649	3,554	3,488	3,086
NM VOC	3,750	2,156	1,662	1,413	1,402	1,347	1,296	1,284
NO _x	2,942	2,209	1,911	1,581	1,584	1,521	1,465	1,367
SO ₂	5,312	1,725	656	539	543	517	507	448

Table 11: Changes in emissions of direct and indirect greenhouse gases and SO₂ in Germany, since the relevant reference years

Emissions change with respect to the reference year / previous year (%)	Reference year	Reference year until 2008	Reference year until 2009	With regard to the previous year (2008 – 2009)
Net CO ₂ emissions / storage	1990	-14.6	-20.2	-6.5
CO ₂ emissions (not including LULUCF)	1990	-18.6	-24.3	-7.0
CH ₄	1990	-52.2	-54.5	-4.8
N ₂ O	1990	-23.3	-23.8	-0.7
HFCs (CO ₂ equivalent)	1995	+77.4	+84.8	+4.2
PFCs (CO ₂ equivalent)	1995	-69.6	-75.3	-18.6
SF ₆ (CO ₂ equivalent)	1995	-54.5	-55.4	-2.0
Total emissions with respect to EU burden-sharing ¹⁶	Defined base year	-20.3	-25.3	-6.3
CO	1990	-71.5	-74.8	-11.5
NM VOC	1990	-65.4	-65.8	-1.0
NO _x	1990	-50.2	-53.5	-6.7
SO ₂	1990	-90.5	-91.6	-11.5

2.1 Description and interpretation of trends in aggregated greenhouse-gas emissions

The above-described obligation to reduce greenhouse-gas emissions, in the framework of EU burden-sharing, was fulfilled by 2009, via a reduction of 25.3 %. The various individual

¹⁶ Defined base-year emissions of 1,232,430 Gg CO₂ equivalent, without CO₂ from LULUCF; cf. Chapter □

greenhouse gases differed in terms of their contribution to that development (cf. Table 1), as is reflected in the greenhouse gases' differing shares of the total emissions of any given year. Among the direct greenhouse gases, emissions of those gases that predominate in terms of quantity were markedly reduced, with the strongest reductions occurring for methane. In the main, the reasons for these reductions are found in the following areas:

- Transition from use of solid fuels to use of liquid and gaseous fuels, which have lower emissions, in the period since 1990;
- Growing importance of use of renewable energies and of related substitutions of fossil fuels;
- Increased plant (installation) efficiencies;
- Changes in animal-housing methods, and reductions of livestock populations;
- Changes in the underlying data for the waste-management sector.

Such areas are considered in greater detail in the discussion below of trends for the various individual greenhouse gases. The global economic crisis, which had its first impact in Germany at the end of 2008, had a significant effect on emissions.

Releases of carbon dioxide – the great majority of which are caused by stationary and mobile combustion processes – predominate in the overall picture of greenhouse-gas emissions. Due to a disproportionately large decrease in emissions of the other greenhouse gases, the proportion of total greenhouse gases attributable to CO₂ emissions has increased since 1990 (cf. Table 2). All other greenhouse gases together account for only about one-tenth of greenhouse-gas emissions. This spectrum of distribution of greenhouse-gas emissions is typical for a highly industrialised country.

2.2 Description and interpretation of emission trends, by greenhouse gases

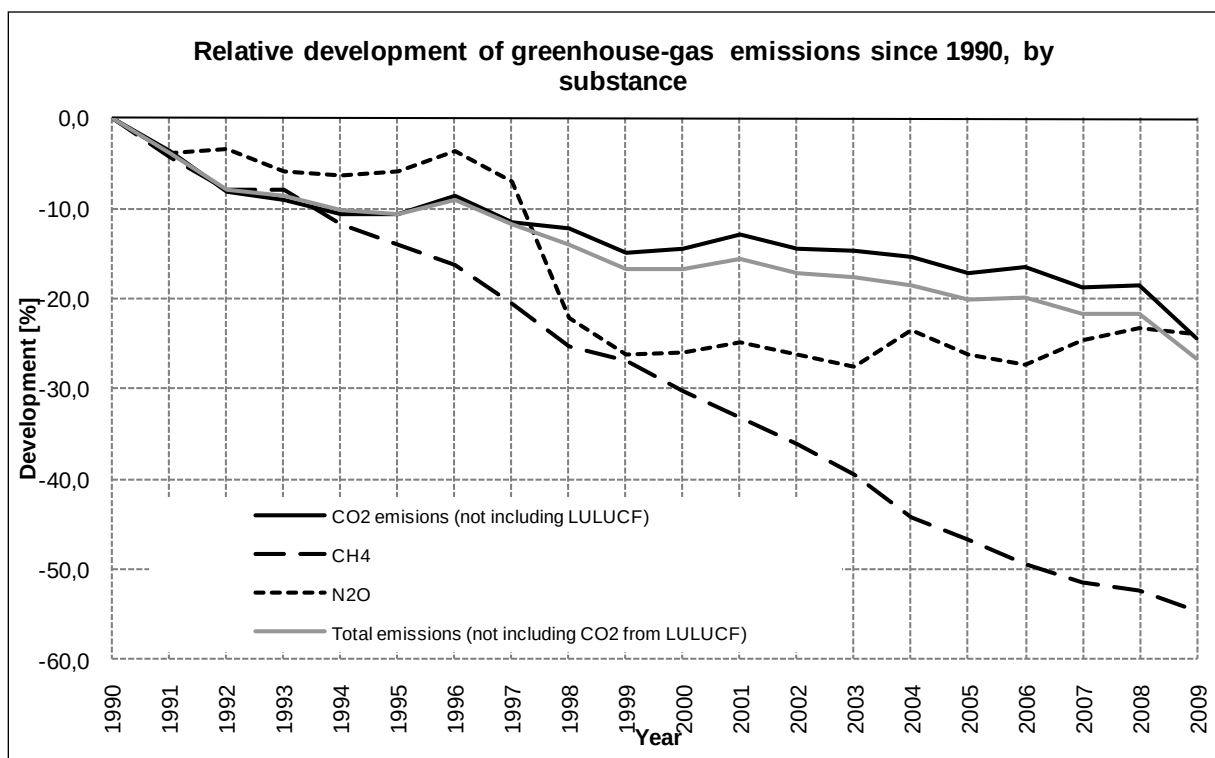


Figure 16: Relative development of greenhouse gases in comparison to their levels in 1990

Figure 16 shows the relative development of emissions of the various greenhouse gases since 1990. In the discussion, it must be remembered that the development of each of these greenhouse gases as shown here is largely dominated by specific developments in a single source category.

2.2.1 Carbon dioxide (CO₂)

The reduction in CO₂ emissions is closely linked to trends in the energy sector. The sharp emissions reduction seen throughout the entire energy sector in the early 1990s was primarily the result of restructuring in the new German Länder, including related conversions to cleaner fuels and decommissioning of obsolete facilities. This trend has continued, to a somewhat lesser degree, through the current report year.

Use of gases, primarily natural gas, as substitutes for solid and liquid fuels is also reflected in emissions trends for stationary combustion systems. While CO₂ emissions from liquid fuels decreased by about one-fourth, with respect to their levels in 1990, and emissions from solid fuels decreased by almost half, emissions from gaseous fuels increased by nearly fifty percent.

When these emissions trends are viewed at the source-category level, a highly consistent picture emerges. In comparison to 1990 levels, emissions in all source categories of energy-related emissions decreased by a total of 254 million t CO₂.

Comparable, but specific (when seen at the detailed level), developments took place in the transport sector. CO₂ emissions increased slightly from 1990 to 1999. Since then, they have fallen significantly below their outset level, to 152 million t, as a result of decreases in consumption; of shifting, by consumers, of fuel purchases to other countries; by substitution of diesel fuel for petrol; and by increasing use of biodiesel. Diesel fuel's share of total fuel consumption in road transports has increased sharply throughout the entire period in question. In 1990, nearly 2/3 of all road-traffic emissions were still being caused by petrol consumption. Now, the relationship is nearly reversed, and diesel emissions predominate.

Trends, taking account of changes with respect to the previous year of the reporting period

With respect to the previous year, emissions in all economic sectors decreased - in part, considerably - as a result of the economic crisis. These decreases have completely outweighed other influencing factors.

In the area of small combustion systems, in the residential area and in the areas of commerce, trade and services, emissions decreased with respect to the previous year, also has a result of lower heating-oil sales.

Trend changes resulting from recalculations

Although extensive recalculations were carried out in connection with allocation of CO₂ emissions from the iron and steel sector, the overall trend changed hardly at all. At the same time, the trend was markedly affected in some intermediate years.

2.2.2 Nitrous oxide (N₂O)

Since 1990, N₂O emissions have decreased by about 24 %. The main emissions areas/sources include agriculture – use of nitrogen-containing fertilisers, and animal

husbandry; the chemical industry; and use of fossil fuels. Smaller amounts of emissions are caused by wastewater treatment and product use of N₂O (for example, as an anaesthetic). Industry has the greatest influence on emissions reductions, especially in the area of adipic acid production. Via technological reduction measures, the chemical industry's emissions were reduced by about two-thirds, with respect to 1990. Since 1999, emissions trends have been strongly influenced by economic trends in the chemical industry sector.

Trends, taking account of changes with respect to the previous year of the reporting period

With respect to the previous year, emissions in nearly all economic sectors decreased. These decreases have completely outweighed other influencing factors. Nitrous oxide emissions increased only in the chemical industry.

2.2.3 Methane (CH₄)

Methane emissions are caused mainly by animal husbandry in agriculture, waste landfilling and distribution of liquid and gaseous fuels; the role of energy-related and process-related emissions is almost negligible. Methane emissions have been decreased by 54.5 % since 1990. This trend was primarily the result of environmental-policy measures (waste separation, with intensified recycling and increasing energy recovery from waste) that decreased landfilling of organic waste. A second key reason is that use of mine gas from coal mining, for energy recovery, has increased. Emissions in this area have decreased by over 80 % since 1990. Yet another reason for the emissions reductions is that livestock populations in the new Federal Länder were reduced, especially in the first half of the 1990s. Repairs and modernisations of outdated gas-distribution networks in that part of Germany, along with improvements in fuel distribution, have brought about further reductions of total emissions.

Trends, taking account of changes with respect to the previous year of the reporting period

In comparison to the previous year, emissions decreased by 4.8 %. That development is due to reductions of emissions from hard-coal mining and to further decreases in landfill emissions.

2.2.4 F gases

Figure 17 shows emissions trends for so-called "F" gases for the period 1995-2009. HFC emissions increased primarily as a result of intensified use of HFCs as refrigerants in refrigeration systems and of increasing disposal of pertinent systems. This more than offset emissions reductions resulting from their reduced use in PUR installation foams. The emissions reductions for PFCs were achieved primarily through efforts of primary aluminium producers and semiconductor manufacturers. The SF₆ emissions reduction until 2003 is due primarily to decreasing use of the gas in automobile tyres since the mid-1990s. In this area, efforts to increase environmental awareness have been successful, resulting in emissions reductions of over 100 t and greenhouse-gas reductions of 2.5 million t of CO₂ equivalents. Similar success has been achieved with soundproof windows, for which production use of SF₆ has been reduced to nearly zero since 1995. At the same time, increasing emissions must be expected in the next few years as a result of increasing disposal of old sound-proof windows. And a large share of current and future emissions of this substance (will) result

from open disposal of old windows. Emissions from electricity-transmission facilities also decreased considerably. Important new emissions sources include welding, production of solar cells and production of optical glass fibre. SF₆ emissions have also decreased in recent years. In the long term, emissions are expected to increase sharply, however, as disposal of sound-proof windows increases.

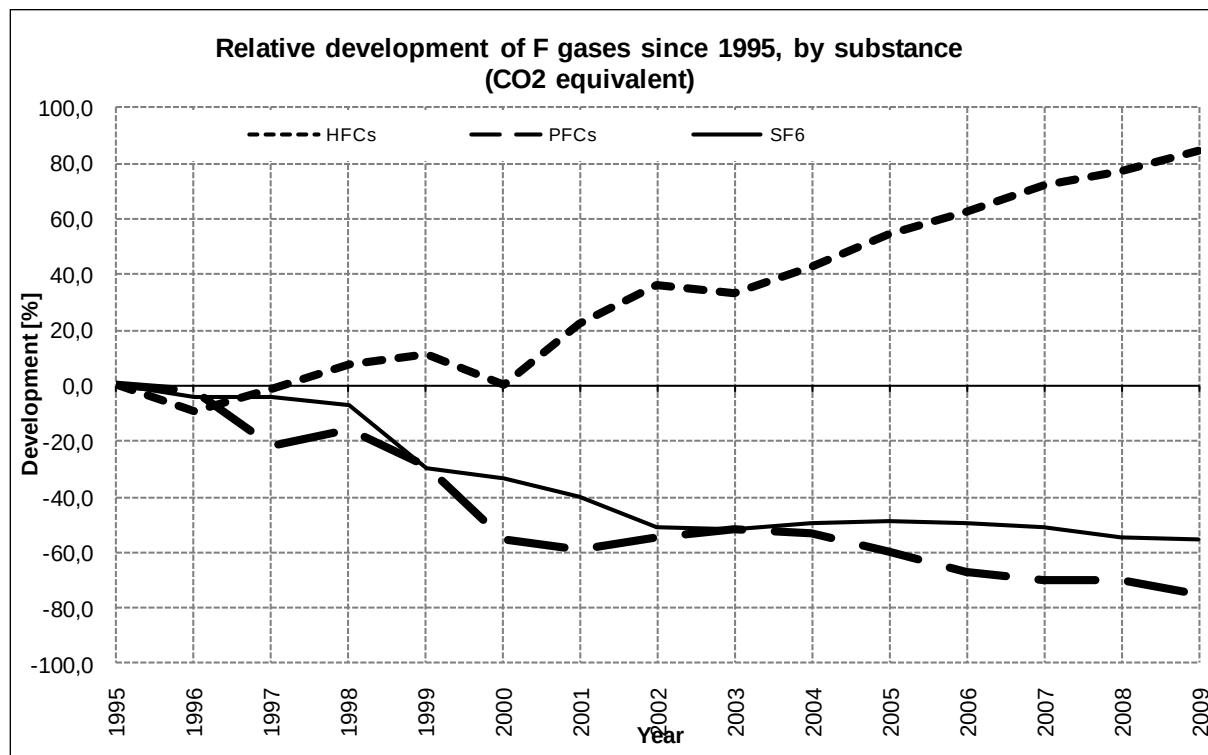


Figure 17: Relative development of F gases in comparison to relevant 1995 levels

Trend changes resulting from recalculations

In the area of secondary aluminium production (2.C.4), inclusion of waste-gas-treatment systems in the inventory has considerably reduced SF₆-emissions figures.

2.3 Description and interpretation of emissions trends, by source categories

Energy

In the category of energy-sector emissions, which have been decreasing, combustion-related emissions are governed primarily by CO₂ emissions from stationary and mobile combustion systems (cf. also the results of the key-source analysis). On the other hand, emissions of other greenhouse gases are negligible in this sector. This situation is reversed for energy-related emissions that are not combustion-related (source category 1.B.). In this area, CO₂ emissions are very low, while emissions trends are clearly shaped by CH₄ emissions caused by distribution of liquid and gaseous fuels. On the whole, energy-related emissions of all greenhouse gases have decreased by nearly 25.5 % since 1990. For combustion-related emissions, this has been achieved through fuel changeovers and higher energy and technical efficiencies, and through increasing use of zero-emissions energy sources, whereas for distribution emissions it has resulted from increased use of mine gas,

modernisation of gas-distribution networks and introduction of vapour-recovery systems in fuel distribution.

Table 322 in the Annex shows the relevant emissions changes, in comparison to the previous year, for the period since 1990. For CO₂ from the energy sector, for example, it is clear that largely temperature-related fluctuations over time – especially variations in winter temperatures – influence heating patterns. Such fluctuations thus affect energy consumption for indoor heating, thereby having a major impact on annual trends in energy-related emissions.

Industrial processes

In the area of emissions from industrial processes, carbon dioxide and nitrous oxide are the predominant greenhouse gases. Relatively noticeable changes in emissions of F gases, on the other hand, have no major impacts on overall trends, because such emissions account for only a small share of total emissions. Methane emissions also play an insignificant role in this context.

Emissions from industrial processes are closely tied to production levels. In particular, CO₂ emissions tend to reflect economic trends; emissions tend to decrease from the previous year as production decreases, especially in the iron and steel industry, chemical industry and cement industry.

The trend for N₂O emissions was decoupled from production, as adipic acid producers' emissions-reducing measures began taking effect. In this respect, in 1997 producers in Germany completed a process of retrofitting their production systems with emissions-reduction equipment. The positive trend is being increasingly offset by production increases, however. Since 1990, N₂O emissions have decreased by about two-thirds.

Since 1990, emissions for the totality of all industrial processes and greenhouse gases, in GG equivalents, have been reduced by about 22.4 %. In comparison to the previous year, the decrease amounted to 10.6 %. The change with respect to the previous year was primarily the result of production decreases in the iron and steel industry.

Solvent and other product use

Also since 1990, emissions in the area of solvent and product use have decreased by about 60 %. Among the emissions tallied in the present context, indirect CO₂ emissions from use of solvents (NMVOC) predominate (those emissions accounted for a share of about 2/3). Emissions from use of N₂O as an anaesthetic decreased by nearly 44 % since 1990. That is the result of balancing (accounting) for the years 1990 and 2001.

Agriculture

The decrease in agricultural emissions since 1990, amounting to over 16 %, is due primarily to reductions in livestock populations, although it is also due to reductions in emissions from agricultural soils and from fertiliser use.

Land use, land-use changes and forestry

The reduction in storage of greenhouse gases via land-use changes and forestry is due primarily to a reduction of sink function in the category "forestland remaining forestland".

Waste and wastewater

The most significant emissions reduction, at 72.7 %, occurred in the area of waste emissions. In that area, intensified recycling of recyclable materials ("yellow sack" for recyclable materials, Ordinance on Packaging, etc.), and the ban, in effect since June 2005, on landfilling of biodegradable waste, have reduced annual quantities of landfilled waste. All in all, these factors have reduced landfill emissions by over 70 %. Emissions from wastewater treatment, which also belong to this source category, are considerably lower, in terms of amounts, than landfill emissions. At the same time, they decreased by nearly half.

Table 12: Changes in greenhouse-gas emissions in Germany, by source categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990; change in %	1990	1995	2000	2005	2006	2007	2008	2009
1. Energy	0,0	-11,4	-15,8	-18,9	-18,5	-20,8	-20,6	-25,4
2. Industrial processes	0,0	2,6	-18,4	-14,6	-13,3	-10,5	-13,2	-22,4
3. Solvent and other product use	0,0	-20,6	-35,0	-54,2	-53,7	-56,5	-59,5	-60,1
4. Agriculture	0,0	-11,9	-11,0	-15,4	-17,2	-17,6	-14,1	-16,2
5. Land use, land-use changes & forestry								
CO ₂ (net sink)								
N ₂ O & CH ₄	0,0	-0,9	-0,8	-1,1	-16,8	25,8	-0,1	-47,3
6. Waste	0,0	-7,6	-37,2	-59,2	-63,4	-66,8	-69,4	-72,7

Emissions change, in each case with respect to the previous year; change in %	1990	1995	2000	2005	2006	2007	2008	2009
1. Energy	0,0	-0,3	-0,3	-1,9	0,6	-2,8	0,3	-6,1
2. Industrial processes	0,0	-1,9	3,8	-3,2	1,6	3,3	-3,1	-10,6
3. Solvent and other product use	0,0	0,2	-8,1	-6,5	1,1	-6,0	-7,0	-1,5
4. Agriculture	0,0	3,1	-0,1	-0,9	-2,2	-0,4	4,3	-2,4
5. Land use, land-use changes & forestry								
CO ₂ (net sink)								
N ₂ O & CH ₄	0,0	-0,5	0,2	-0,1	-15,9	51,2	-20,6	-47,3
6. Waste	0,0	-3,6	-6,0	-9,6	-10,4	-9,1	-8,0	-10,8

The relevant detailed data are presented in Table 323 in Annex Chapter 22.3.

2.4 Description and interpretation of trends in emissions of indirect greenhouse gases and of SO₂

The relative development of emissions of indirect greenhouse gases and SO₂ are graphically depicted, in each case as time series since 1990, in Figure 18 and in Table 11. Over this period, considerable reductions of emissions of these pollutants have been achieved. For example, emissions of SO₂ have been reduced by over 91 %, those of CO by over 74 %, those of NMVOCs by about 65 % and those of NO_x by over 56 %.

The vast majority of emissions of sulphur dioxide, nitrogen oxide and carbon monoxide are combustion-related. In the category of NMVOC emissions, however, solvent use is the most important emissions factor.

A range of different factors are responsible for this trend. These factors, which differ in the significance and extent of their relevance, include:

- As a result of Germany's reunification in 1990, emissions from the territory of the former GDR in particular made the starting level relatively high.

- In the years that followed, obsolete industrial facilities in the eastern part of Germany were decommissioned. They were replaced, in the great majority of cases, with state-of-the-art new facilities. Non-decommissioned old installations were extensively retrofitted with emissions-reduction and efficiency-enhancing equipment.
- In addition, fuel mixes were changed – in eastern Germany in particular, local-lignite fractions were reduced in favour of energy carriers such as natural gas and petroleum, which produce fewer emissions.
- In the traffic sector, newer vehicles equipped with pollutant-reducing technology were used.
- In the years since 1990, the immission-protection provisions of the former Federal Republic of Germany have become legally binding for eastern Germany. Following the expiration of provisional rulings, applicable laws were repeatedly adapted in keeping with technological progress.
- Established legal regulations and market-economic incentives led to thriftier use of energy and raw materials.
- International legislation, particularly from the European Community, has had an emission-reducing effect (e.g. the NEC Directive).
- Increasing use of zero-emissions energy sources (electricity/heat from solar and wind systems, and from geothermal systems) has also had an impact on emissions of indirect greenhouse gases, especially in recent years.

Descriptions of the emission calculations for these pollutants, along with additional, detailed parameters influencing the emissions trends for the various individual air pollutants involved, are provided by the Web site of the Federal Environment Agency.

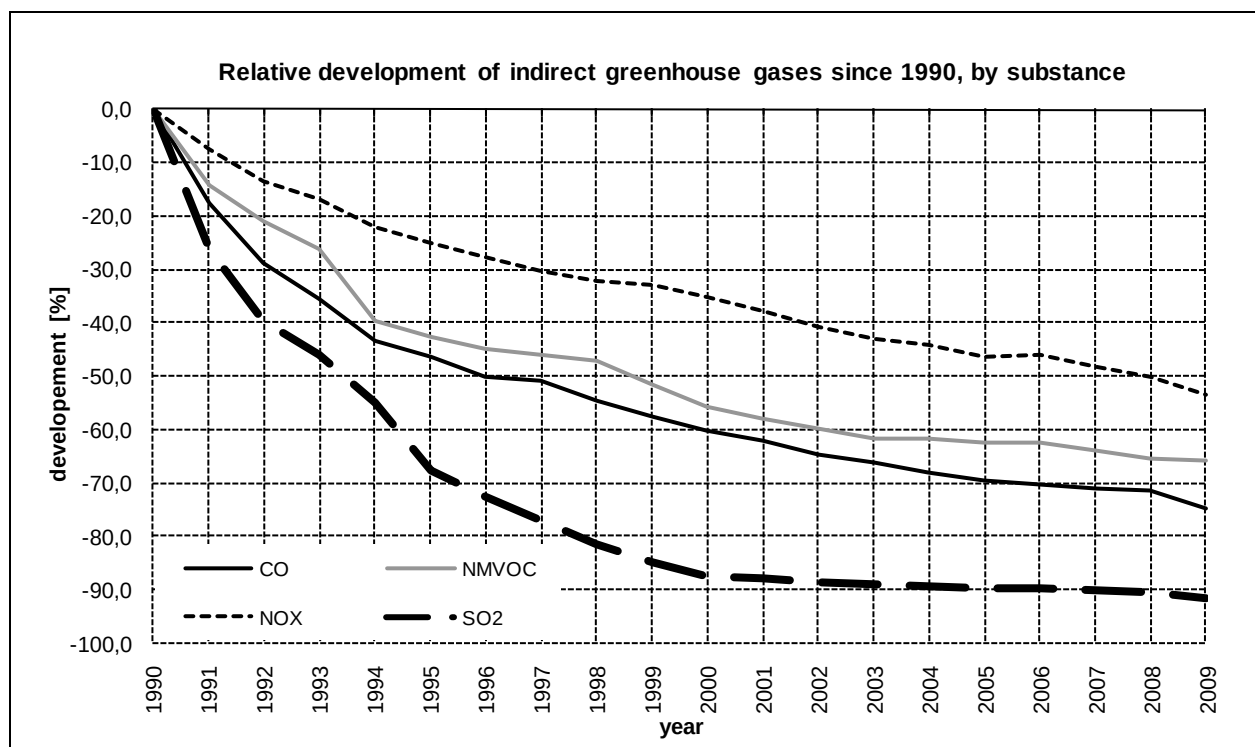


Figure 18: Emissions trends for indirect greenhouse gases and SO₂

2.5 Description and interpretation of emissions trends with regard to the KP-LULUCF inventory, for aggregated emissions and by activity and greenhouse gas

Germany reports under KP-LULUCF Article 3 (3), and it reports in the area of forest management with regard to the selected additional activities pursuant to Article 3 (4) Kyoto Protocol. It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

Under Article 3.3, it reports storage of 3,713.55 Gg CO₂ equivalent. The emissions are composed of storage of CO₂ via afforestation and reafforestation, amounting to 4,779.19 Gg CO₂ equivalent, and emissions from deforestation, amounting to 1,065.64 Gg CO₂ equivalent. Under Article 3.3, it reports CO₂ storage of -3,717.39 Gg CO₂ equivalent and N₂O emissions of 3.85 Gg CO₂ equivalent.

Under Article 3.4, it reports storage of 20,526.72 Gg CO₂ equivalent. The relevant storage consists of CO₂ storage of 21,240.13 Gg CO₂ equivalent and emissions of 713.41 Gg CO₂ equivalent. Under Artikel 3.4, it reports CO₂ storage of 20,576.98 Gg CO₂ equivalent, N₂O emissions of 45.65 Gg CO₂ equivalent and CH₄ emissions of 4.62 Gg CO₂ equivalent.

Table 13: Emissions in 2008 and 2009 for the KP-LULUCF activities afforestation and deforestation, pursuant to Article 3.3, and for forest management, pursuant to Article 3.4.

Source category	Emissions 2008 [Gg CO ₂ equivalent]	Emissions 2009 [Gg CO ₂ equivalent]
KP 3.3 Afforestation/Reforestation	-4,476.40	-4,779.19
KP 3.3 Deforestation	1,079.81	1,065.64
KP 3.4 Forest Management	-20,639.78	-20,625.65

On afforestation areas, a storage increase of 302.79 Gg CO₂ equivalent was determined for the period from 2008 to 2009. That positive trend is also seen in the area of deforestation, in which emissions decreased slightly, by 14.17 Gg CO₂ equivalent. On the other hand, storage in connection with forest management decreased slightly from 2008 to 2009. The decrease amounts to 14.13 Gg CO₂ equivalent (cf. Table 13).

3 ENERGY (CRF SECTOR 1)

3.1 Overview (CRF Sector 1)

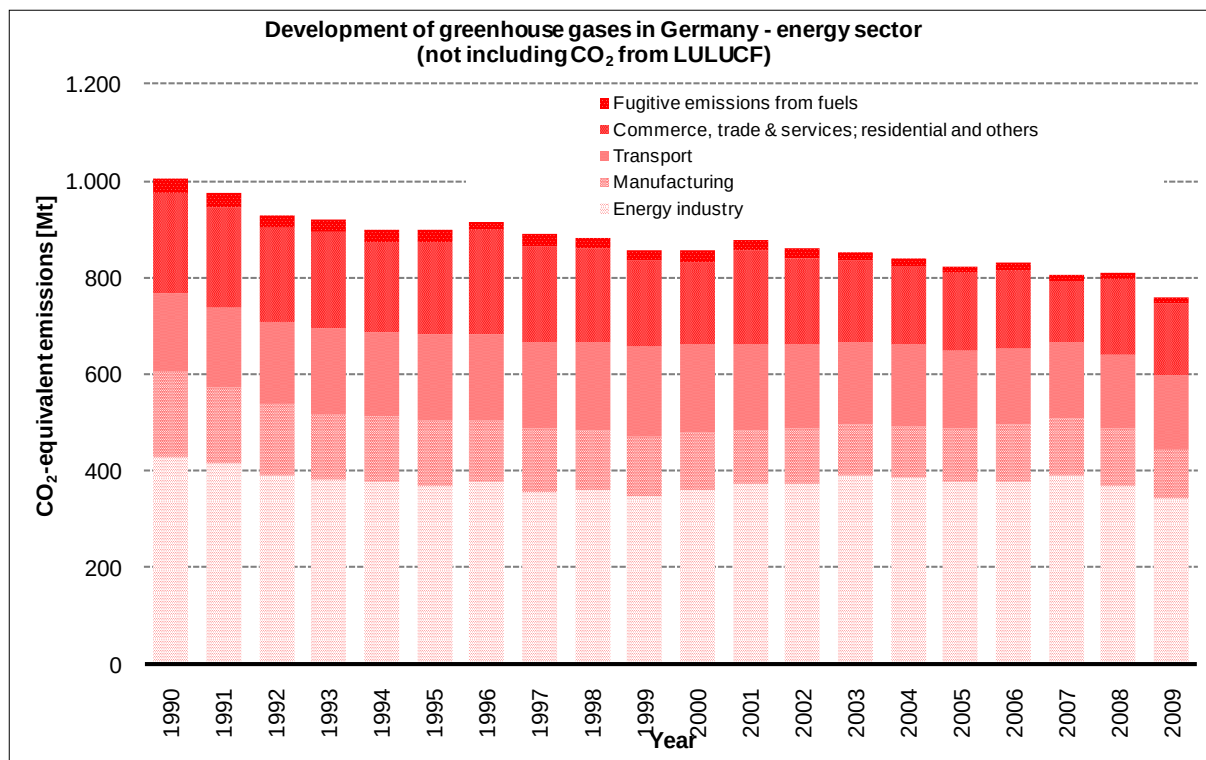


Figure 19: Overview of greenhouse-gas emissions in CRF sector 1

For determination of activity data from combustion, different models are used for mobile and stationary sources. The model used for stationary sources is the "Balance of Emissions Causes" ("Bilanz der Emissionsursachen" – BEU), while the model used for mobile sources is the "Transport Emission Estimation Model" (TREMOD). In both models, combustion-related activities are determined and then recorded in the "Central System of Emissions" (CSE) emissions database.

Within the CSE, relevant emissions are then calculated by multiplying these combustion-related activities by the pertinent emission factors (as taken from the list of CO₂-emission factors in the National Allocation Plan). In the process, complete oxidation of the carbon contained in the fuels is assumed.

3.2 Combustion of fuels (1.A)

The activity data for stationary combustion are calculated in the "Balance of Emissions Causes" (BEU) model. The database for this model, which was developed by the Federal Environment Agency, consists of the Energy Balance of the Federal Republic of Germany. The Energy Balance is described in detail in Chapter 18.

With the help of additional statistics, and of various assumptions, these data are then further disaggregated and supplemented for the relevant energy-transformation and final-consumption sectors. Relevant criteria for this work include permits under immissions-control laws, technologies and differentiation between certain fuels. The model consists of two parts: a sub-model for the old German Länder, covering the years 1987-1994, and a sub-model for all of Germany, covering the years as of 1995. The model for all of Germany has been

revised and, in the reports of two research projects (FKZ 203 41 142: ÖKOINSTITUT, 2005 and 204 41 132: ÖKOINSTITUT / DIW, 2007), comprehensively documented. In 2009, for the first time, relevant calculations were carried out with the help of a database-supported system of the BEU that is based on MESAP software and that was developed in the framework of the research projects FKZ 204 42 203/03 and FKZ 360 16 010 (GICON, 2008), via an approach similar to that used for the sub-model for Germany. Data for the new German Länder, for the period 1990-1994, have already been entered into the CSE. The manner in which those data were obtained is described in detail in Chapter 11.

The following Energy Balance lines are used for determination of emissions-relevant fuel inputs from stationary sources:

A: Transformation inputs (Energy Balance lines 9 through 19)

1. **Public thermal power stations** (line 11) are plants whose operators are sited within the public utility sector. This category also includes industrial plants which operate their power stations together with electricity utility companies, as joint-venture power stations. The fuel input for electricity generation is reported here. This line of the Energy Balance also includes the fuel input in public thermal power stations attributable to electricity production.
2. **Industrial thermal power stations** (line 12) comprise the following operator groups:
 - a) Power stations in the hard-coal-mining sector,
 - b) Power stations in the lignite-mining sector,
 - c) Power stations in the petroleum-processing sector (refinery power stations),
 - d) Power stations that generate single-phase power for Deutsche Bahn AG (German Railways) (until 1999, the relevant input amounts for Deutsche Bahn power stations were reported under 1A2f (EB line 12); as of 2000, they have been reported together with public power stations under 1A1a (EB line 11)),
 - e) Industrial power stations (quarrying, other mining, manufacturing industry).
3. **Hydroelectric, wind-power, photovoltaic systems and other similar systems** (line 14) comprises all systems/plants that generate electricity from biogas, landfill gas, sewage-treatment gas or liquid biomass and feed the electricity into the public grid. Since no cut-off limit applies for such systems, this category includes very small systems in the residential and commercial/institutional sectors.
4. **Thermal (CHP) power stations** (line 15): only the fuel input which can be allocated to district heat generation is given. Adding lines 11 and 15 together produces the total fuel input in public thermal power stations. The district heat generated is fed into the public heating grid. These stations also supply industrial customers with process heat.

5. **District heating stations** (line 16): here, the fuel input for the public district heat supply, from heating stations, is given. The facilities are often used to cover peak loads in district heating networks in which the basic load is met by thermal power stations.
6. **Other energy producers** (line 19) comprises all systems/plants that generate electricity from solid biomass and feed the electricity into the public grid.

B: Energy consumption in the transformation sector (Energy Balance lines 33 through 39)

7. Lines 33 to 39 and the total line 40 (**energy consumption in the transformation sector**) include the fuel input for heat generation which is needed to operate the transformation stations. No distinction is made here with regard to the type of heat generation involved. This means that fuel inputs for heat generation in combined heating and power stations, steam and hot water boilers and process firing installations are combined. There is an inconsistency in the Energy Balance with respect to summing-up for lignite pits and briquette plants. Until 1979, the Energy Balance showed fuel inputs for lignite drying together with other own consumption of lignite pits and briquette plants, in line 35 (energy consumption in the transformation sector). Since 1980, this own consumption has been listed together with production-related transformation inputs of briquette plants, in line 10. As a result, the emissions-causing inputs within own consumption can no longer be read out of the Energy Balance; they must be calculated from the transformation input. The fuel inputs used to generate heat in combined heat and power generation stations, together with fuel inputs used for electricity generation by the power stations of hard coal pits, lignite pits and refinery power stations, combine to form the total fuel input in such plants. Deduction, from the total listed in line 40, of fuel inputs for heat generation in power stations leaves the quantity of fuel used in process firing installations, steam and hot water boilers.

C: Final energy consumption (Energy Balance lines 46 through 67)

8. **Final energy consumption by industry** (line 60 of the Energy Balance) refers to the fuel used for heat generation which is required for both production purposes and space heating. Here as well, no distinction is made with regard to the type of heat generation involved. Hence, a part of the final energy consumption in these source categories, together with industrial power stations' fuel input for generating electricity, constitutes the total fuel input in such facilities.
9. The data on **final energy consumption in the residential sector** (line 66 of the Energy Balance) comprise fuel inputs for heat generation and include the application areas of heating, water heating and cooking.

10. The data on **final energy consumption by trade, commerce, services and other consumers** (line 67 of the Energy Balance) comprises fuel inputs used for hot water production, room heating and process heat generation in this sector.

The Energy Balance data scheme is no longer able to accommodate all of the diverse requirements of national and international energy and emissions reporting. For example, the Energy Balance combines fuel inputs

- In facilities with different requirements under immission protection legislation (e.g. large furnaces, medium-sized furnaces, small furnaces, waste incineration plants)
- In plants that operate according to different technical principles (e.g. steam turbine power stations, gas turbine power stations, combustion-engine stations)
- That exhibit regional peculiarities (e.g. different individual mining regions have different qualities of crude lignite)
- With different source-category allocations in national and international emissions reporting
- That are listed in different Energy Balance lines, in keeping with their intended purpose (for electricity or heat generation), but are used in a single facility group (e.g. steam turbine power stations).

These characteristics have impacts on emissions behaviour. In order to make allowance for the various differing requirements that thus arise, the Energy Balance data in the model *Balance of Emission Causes* (BEU) are disaggregated, using additional statistics as well as the Federal Environment Agency's own calculations. The following Figure 20 provides an overview of the relevant structure:

Balance of emission causes (BEU)
The source categories include: • Public thermal power stations, • Hard coal mining, • Lignite mining, • Deutsche Bahn AG (until 1999), • Petroleum oil refineries, • District heating stations, • Other energy transformation • Quarrying of non-metallic minerals, other mining and manufacturing industry (further sub-classification of process combustion), (The residential, commercial/institutional and other consumers sectors are listed and analysed directly within the CSE, outside of the BEU model.)
The types of facilities involved include: • Steam turbine power stations, • Gas turbine power stations, • Gas and steam turbine power stations, • Motor power stations, • Boiler furnaces (excluding power station boilers), • Process furnaces (sub-classified into 12 processes).
By fuels/energy sources: • About 40 different fuels
On the basis of immission protection legislation provisions, the following are differentiated: • Facilities under the 1st Ordinance on the Execution of the Federal Immission Control Act (13. BImSchV), • Facilities under the 1st Ordinance on the Execution of the Federal Immission Control Act (17. BImSchV), • Facilities under the 1st Ordinance on the Execution of the Federal Immission Control Act (1. BImSchV), • Installations under the Technical Instructions on Air Quality Control (TA Luft)
Abbreviations: BImSchV Ordinance on the Execution of the Federal Immission Control Act TA-Luft First General Administrative Provision on the Federal Immission Control Act (Clean Air Directive)

Figure 20: Characteristics of the Federal Environment Agency's structure of the Balance of Emission Causes, for disaggregation of the Energy Balance

The BEU model is designed to provide a data structure that can be used in meeting a range of different reporting obligations. In particular, surveys of "classical" air pollutants have necessitated finer disaggregation.

Despite the conversion of the Energy Balance to the classification of industrial sectors (WZ 93) and altered grouping of energy resources from the year 1995 onwards, it has been possible to fit the data within the outlined basic structure; this has facilitated preparation of consistent time series.

Figure 20 and the following tables (Table 14 through Table 20) show the BEU's structural features. These basic structures are analysed in greater detail in the relevant descriptions of activities. The following should be noted in reading the tables:

The number in the third column is the line number of the Energy Balance from which the basic data for calculation in the *Balance of Emission Causes* table are taken. The column "SWK" (S = fuel input for electricity generation, W = fuel input for heat generation, K = fuel input for machine action) shows the use in question. The last column shows the names of the relevant calculation procedures; in each case, these provide a unique reference to the database of the *Central System on Emissions (CSE)*.

Table 14: Structure of the Balance of Emissions Causes – public services – source category 1.A.1.a

Process, fuel	EB line	Allocation under emissions laws	Type of facility ¹⁾	Economic sector	SWK ²⁾
Public supply					
Electricity generation in large combustion systems of public power stations	11	13. BImSchV	DTKW	Public supply	S
Electricity generation in waste incineration systems of public power stations	11	17. BImSchV	DTKW	Public supply	S
Electricity generation in gas turbines (TA Luft) of public power stations	11	TA Luft	GTKW	Public supply	S
Electricity generation in gas and steam turbine systems (TA Luft) of public power stations	11	TA Luft	GuD	Public supply	S
Electricity generation in large combustion systems of gas turbines of public power stations	11	13. BImSchV	GTKW	Public supply	S
Electricity generation in large combustion systems of gas and steam turbine systems of public power stations	11	13. BImSchV	GuD	Public supply	S
Electricity generation in gas engines of public power stations	11	TA Luft	GMA	Public supply	S
Electricity generation in diesel engines of public power stations	11	TA Luft	DMA	Public supply	S
Electricity generation in public biomass-fired power stations	11	17. BImSchV	DTKW	Public supply	S
Co-combustion in public power stations	11	17. BImSchV	DTKW	Public supply	S
Feed-in into the public grid	14	TA Luft	GMA	Public supply	S
Heat generation in diesel engines of public power stations	15	TA Luft	DMA	Public supply	W
Heat generation in large combustion systems of public power stations	15	13. BImSchV	DTKW	Public supply	W
Heat generation in large combustion systems of public crude-lignite-fired power stations	15	13. BImSchV	DTKW	Public supply	W
Heat generation in waste-incineration systems of public power stations	15	17. BImSchV	DTKW	Public supply	W
Heat generation in gas turbines (TA Luft) of public power stations	15	TA Luft	GTKW	Public supply	W
Heat generation in gas and steam turbine systems (TA Luft) of public power stations	15	TA Luft	GuD	Public supply	W
Heat generation in large combustion systems of gas turbines of public power stations	15	13. BImSchV	GTKW	Public supply	W
Heat generation in large combustion systems of gas and steam turbine systems of public power stations	15	13. BImSchV	GuD	Public supply	W
Heat generation in gas engines of public power stations	15	TA Luft	GMA	Public supply	W
Heat generation in public biomass-fired power stations	15	17. BImSchV	DTKW	Public supply	W
Co-combustion in public power stations	15	17. BImSchV	DTKW	Public supply	W
Heat generation in gas engines of public district heating stations	16	TA Luft	GMA	Public supply	W
Heat generation in large combustion systems of public district heating stations	16	13. BImSchV	FHW	Public supply	W
Heat generation in waste-incineration systems of public district heating stations	16	17. BImSchV	FHW	Public supply	W
Heat generation in TA Luft systems of public district heating stations	16	TA Luft	FHW	Public supply	W
Heat generation in public biomass-fired thermal power stations	16	17. BImSchV	FHW	Public supply	W
Co-combustion in public district heating stations	16	17. BImSchV	FHW	Public supply	W
Feed-in into the public grid	19	TA Luft	DTKW	Public supply	S

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces

2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 15: Structure of the Balance of Emissions Causes – refineries – source category 1.A.1.b

Process, fuel	EB line	Allocation under emissions laws	Type of facility ¹⁾	Economic sector	SWK ²⁾
Refineries					
Electricity generation in large combustion systems of refinery power stations	12	13. BImSchV	DTKW	Manufacture of refined petroleum products	S
Electricity generation in TA Luft systems of refinery power stations	12	TA-Luft	DTKW	Manufacture of refined petroleum products	S
Electricity generation in gas turbines (TA Luft) of refinery power stations	12	TA Luft	GTKW	Manufacture of refined petroleum products	S
Electricity generation in large combustion systems of gas turbine systems of refinery power stations	12	13. BImSchV	GTKW	Manufacture of refined petroleum products	S
Heat production in large combustion systems of refinery power stations	40	13. BImSchV	DTKW	Manufacture of refined petroleum products	W
Heat generation in TA Luft systems of refinery power stations	40	TA-Luft	DTKW	Manufacture of refined petroleum products	W
Heat generation in gas turbines (TA Luft) of refinery power stations	40	TA Luft	GTKW	Manufacture of refined petroleum products	W
Heat generation in large combustion systems of gas turbine systems of refinery power stations	40	13. BImSchV	GTKW	Manufacture of refined petroleum products	W
Heat generation in diesel motors of refinery power stations	40	TA Luft	DMA	Manufacture of refined petroleum products	W
Refinery bottom-heating systems (large combustion systems)	40	13. BImSchV	PF	Manufacture of refined petroleum products	W
Refinery bottom-heating systems (TA Luft installations)	40	TA Luft	PF	Manufacture of refined petroleum products	W

- 1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces
- 2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 16: Structure of the Balance of Emissions Causes – coal mining and other transformation sector – source category 1.A.1.c

Process, fuel	EB line	Allocation under emissions laws	Type of facility ¹⁾	Economic sector	SWK ²⁾
Coal mining					
Electricity generation in large combustion systems of power stations of the hard-coal-mining sector	12	13. BImSchV	DTKW	Coal mining	S
Electricity generation in TA-Luft systems of power stations of the hard-coal-mining sector	12	TA Luft	DTKW	Coal mining	S
Electricity generation in large combustion systems of mine power stations	12	13. BImSchV	DTKW	Other coal mining	S
Electricity generation in gas engines of colliery and mine power stations	12	TA Luft	GMA	Coal mining	S
Co-combustion in mine power stations	12	17. BImSchV	DTKW	Other coal mining	S
Heat generation in large combustion systems of mine power stations	40	13. BImSchV	DTKW	Other coal mining	W
Heat generation in large combustion systems of power stations of the hard-coal-mining sector	40	13. BImSchV	DTKW	Coal mining	W
Heat generation in gas engines of power stations of the hard-coal-mining sector	40	TA Luft	GMA	Coal mining	w
Direct drive via diesel engines of colliery and mine power stations	40	TA Luft	DMKW	Coal mining	K
Co-combustion in mine power stations	40	17. BImSchV	DTKW	Other coal mining	W
Production of hard-coal coke	40	TA Luft	PF	Coal mining / iron and steel industry	W
Other energy transformation					
Heat generation in diesel engines of the other transformation sector	40	TA Luft	DMA	Other energy producers	W
Heat generation in gas engines of the other transformation sector	40	TA Luft	GMA	Other energy producers	W
Heat generation in TA Luft systems (industrial boilers) of the other transformation sector	40	TA Luft	FA	Other energy producers	W
Own consumption of wastewater-treatment plants	40	TA Luft	GMA	Other energy producers	W

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces

2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 17: Structure of the Balance of Emissions Causes – source categories 1.A.1.a-f

Process, fuel	EB line	Allocation under emissions laws	Type of facility ¹⁾	Economic sector	SWK ²⁾
Other BEU structural elements					
Gas turbines (TA Luft) in natural-gas-compressor stations	40	TA Luft	GT	Gas industry	K
Source category 1.A.2.a					
Pig iron production	60	TA Luft	Blast furnaces	Iron and steel industry	W
Sinter production	60	TA Luft	Sintering plants	Iron and steel industry	W
Manufacturing of rolled steel (process combustion)	60	TA Luft	Production of rolled steel	Steel production	W
Production of iron, steel and malleable cast iron (process combustion)	60	TA Luft	Foundries	Foundry industry	W
Source category 1.A.2.b					
Production of non-ferrous heavy metals (process combustion)	60	TA Luft	Foundries for non-ferrous metals	Non-ferrous-metal production	W
Source category 1.A.2.d					
Electricity generation in large combustion systems of power stations of the pulp and paper industry	12	13. BImSchV	DTKW	Pulp and paper industry	S
Heat generation in large combustion systems of power stations of the pulp and paper industry	60	13. BImSchV	DTKW	Pulp and paper industry	W
Source category 1.A.2.e					
Sugar manufacturing (process combustion)	60	TA Luft	Sugar refineries	Sugar production	W
Source category 1.A.2.f					
Lime production (process combustion)	60	TA Luft	Lime-burning furnaces	Lime production	W
Production of cement clinkers (process combustion)	60	TA Luft	Cement furnaces	Cement production	W
Glass production (process combustion)	60	TA Luft	Glass smelting furnaces	Glass production	W
Ceramics production (process combustion)	60	TA Luft	Kilns	Brick production	W
Other process combustion	60	TA Luft	Process combustion	Other mining and manufacturing	W

1) GT = gas turbines, DTKW = steam turbine power stations

2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 18: Structure of the Balance of Emissions Causes – other industrial power stations and industrial boilers – source category 1.A.2.f Other

Process, fuel	EB line	Allocation under emissions laws	Type of facility ¹⁾	Economic sector	SWK ²⁾
Other industrial power stations					
Electricity generation in large combustion systems of DB power stations	12	13. BImSchV	DTKW	Deutsche Bahn AG (German Railways)	S
Electricity generation in large combustion systems of other industrial power stations	12	13. BImSchV	DTKW	Other mining and manufacturing (not including VAW)	S
Electricity generation in waste incineration systems of other industrial power stations	12	17. BImSchV	DTKW	Other mining and manufacturing	S
Heat generation in TA Luft systems of other industrial power stations	12	TA Luft	DTKW	Other mining and manufacturing	S
Electricity generation in gas turbines (TA Luft) of other industrial power stations	12	TA Luft	GTKW	Other mining and manufacturing	S
Electricity generation in large combustion systems of gas turbines of other industrial power stations	12	13. BImSchV	GTKW	Other mining and manufacturing	S
Electricity generation in gas and steam turbine systems (TA Luft systems) of other industrial power stations	12	TA-Luft	GuDKW	Other mining and manufacturing .	S
Electricity generation in gas and steam turbine systems (large combustion systems) of other industrial power stations	12	13. BImSchV	GuDKW	Other mining and manufacturing .	S
Electricity generation in gas engines of other industrial power stations	12	TA Luft	GMA	Other mining and manufacturing	S
Electricity generation in diesel motors of other industrial power stations	12	TA Luft	DMA	Other mining and manufacturing	S
Incineration of special waste		17. BImSchV	FA	Other mining and manufacturing	S
Heat generation in diesel engines of the other and other mining sectors	60	TA Luft	DMA	Other mining and manufacturing	W
Heat generation in large combustion systems of industrial power stations of the other and other mining sectors	60	13. BImSchV	DTKW	Other mining and manufacturing	W
Heat generation in waste-incineration systems of the manufacturing and other mining sectors	60	17. BImSchV	DTKW	Other mining and manufacturing	W
Heat generation in TA Luft systems of industrial power stations of the manufacturing and other mining sectors	60	TA Luft	DTKW	Other mining and manufacturing	W
Heat generation in gas turbines (TA Luft) of industrial power stations of the other and other mining sectors	60	TA Luft	GTKW	Other mining and manufacturing	W
Heat generation in gas turbines of industrial power stations of the manufacturing and other mining sectors	60	13. BImSchV	GTKW	Other mining and manufacturing	W
Heat generation in gas and steam turbine systems (TA Luft) of industrial power stations of the manufacturing and other mining sectors	60	TA Luft	GuDKW	Other mining and manufacturing	W
Heat generation in large combustion systems of gas and steam turbine systems of industrial power stations of the manufacturing and other mining sectors	60	13. BImSchV	GuDKW	Other mining and manufacturing	W
Heat generation in large combustion systems (industrial boilers) of the manufacturing and other mining sectors	60	13. BImSchV	FA	Other mining and manufacturing	W
Heat generation in TA Luft systems (industrial boilers) of the manufacturing and other mining sectors	60	TA Luft	FA	Other mining and manufacturing	W
Heat generation in gas engines of industrial power stations of the manufacturing and other mining sectors	60	TA Luft	GMA	Other mining and manufacturing	W

- 1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces 2) S = electricity generation, W = heat generation, K = power production (direct drive)

Table 19: Structure of the Balance of Emissions Causes – structural elements already integrated within the CSE – source categories 1.A.4 and 1.A.5.a

Process, fuel	EB line	Allocation under emissions laws	Type of facility ¹⁾	Economic sector	SWK ²⁾
Source category 1.A.4.a					
Heat generation in TA Luft systems of other small consumers	67	TA Luft	Hot-water boilers	Commercial/institutional	W
Heat generation in small combustion systems of other small consumers	67	1. BImSchV	Hot-water boilers	Commercial/institutional	W
Source category 1.A.4.b					
Heat generation in small combustion systems of households	66	1. BImSchV	Heat producing systems	Households	W
Residential, mobile sources	66		Drive		
Source category 1.A.4.c					
Heat generation in TA Luft systems in agricultural and horticultural operations	67	TA Luft	Steam / hot-water boilers	Agriculture	W
Heat generation in small combustion systems in agricultural and horticultural operations	67	1. BImSchV	Steam / hot-water production systems	Agriculture	W
Source category 1.A.5.a					
Heat generation in TA Luft systems of military agencies	67	TA Luft	Hot-water boilers	Military agencies	W
Heat generation in small combustion systems of military agencies	67	1. BImSchV	Hot-water boilers	Military agencies	W

Table 20: Structure of the Balance of Emissions Causes – natural-gas-compressor stations – source category: 1.A.3.e

Process, fuel	EB line	Allocation under emissions laws	Type of facility ¹⁾	Economic sector	SWK ²⁾
Gas turbines (TA Luft) of natural-gas-compressor stations	40	TA Luft	GTr	Gas industry	K
Large combustion systems of gas turbines in natural-gas-compressor stations	40	TA Luft	GT	Gas industry	K

3.2.1 Comparison of the sectoral approach and the Reference Approach

3.2.1.1 Comparison with the CO₂ Reference Approach

Reporting on combustion-related CO₂ emissions is centrally important within the context of international climate protection. To this end, industrialised countries routinely adopt the source-category-specific approach, which addresses the level of individual energy consumption sectors and therefore supports greater differentiation in analysis of emitter structures. To provide a simplified and comparative approach, the Intergovernmental Panel on Climate Change (IPCC) has developed the *Reference Approach*, which is based on primary energy consumption (input of energy resources in a given country).

The Reference Approach was carried out for all years in question. Currently, Energy Balances up to the year 2008 are available. For 2009, the Working Group on Energy Balances has provided a provisional Energy Balance.

The results of the Reference Approach are compiled in Table 21. In Figure 21 and Figure 22, they are compared with the various relevant data records. In an average for all years in question, the discrepancy between the results obtained with the Reference Approach and those obtained with the sectoral calculation approach is 0.5 %. The discrepancies vary throughout a range of - 0.3 % (1995) to + 1.9 % (2003).

3.2.1.2 Quality assurance / control and verification (1.A)

Below, for verification purposes, the results of the detailed source-category-based calculation of energy-related CO₂ emissions for Germany, carried out in accordance with the specifications of the *IPCC Good Practice Guidance* (2000), are compared with other available Germany-relevant national and international data records on energy-related CO₂ emissions for the years 1990 to 2007. For 2008, most of these comparative data have not yet been published.

In the comparison, the calculation results are compared with data:

- from the IEA (source-category-specific approach and Reference Approach)
- from the CO₂ calculations performed at *Länder* level.

Table 21 presents the results of the various CO₂ calculation approaches for comparison. For visualisation purposes, the data is also presented graphically, on a comparative basis over time, in Figure 21. The key development trends emerge in all calculation approaches, including the Reference Approach, albeit at differing levels. In Figure 22, the relative discrepancies in the data records created by the varying calculations are depicted in order to illustrate these level differences.

Nevertheless, on the whole, these comparisons confirm the CO₂ emissions calculated for Germany. The energy-related total emissions, as calculated in detail for the national level, differ, in an average for the years 1990 through 2008, by the following amounts, for the following procedures:

• IEA detailed approach	0.8 %
• IEA Reference Approach	1.2 %
• National Reference Approach	0.5 %
• Results of the Länder	3.1 %

Table 21: Comparison of CO₂ inventories with other independent national and international results for CO₂ emissions

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Results, discrepancy									[millions of t] / [%]										
IEA statistics, SA (sectoral approach)	950.4	941.5	892.6	884.9	871.8	869.3	908.4	879.7	867.6	837.7	827.1	846.3	836.4	842.1	843.4	811.3	823.5	801.1	803.9
Discrepancy between IEA SA and UBA (1.A)	-2.7	-0.3	-0.6	-0.5	0.1	0.0	1.9	2.2	1.6	1.2	0.0	-0.3	0.1	1.6	3.2	1.1	2.0	2.0	2.0
IEA statistics, RA (reference approach)	971.7	937.5	897.5	883.7	870.7	877.5	895.5	870.4	869.9	833.9	843.9	868.4	846.3	849.0	843.5	820.1	821.3	804.1	802.6
Discrepancy between IEA RA and UBA (1.A)	-0.6	-0.7	0.0	-0.6	0.0	0.9	0.4	1.1	1.9	0.7	2.0	2.3	1.3	2.4	3.2	2.2	1.7	2.4	1.9
Discrepancy between IEA RA figures and UBA RA figures	-0.4	-0.5	-0.2	-1.1	-0.5	1.3	0.4	0.8	1.4	0.2	1.4	1.6	0.7	0.5	1.8	0.9	0.1	2.2	2.9
Results of the Länder (energy)	981.7	963.2	917.2	912.5	890.5	893.6	914.6	890.5	887.7	861.3	863.0	887.5	864.4	859.5	847.4	835.8	841.6	820.4	NA
Discrepancy between the Länder figures (energy) and UBA's figures	0.5	2.0	2.2	2.6	2.3	2.8	2.6	3.5	4.0	4.0	4.3	4.5	3.5	3.7	3.7	4.2	4.2	4.5	NA
Reference Approach, UBA (RA)	975.6	942.1	898.9	893.4	875.0	866.7	891.6	863.9	857.5	832.2	832.2	854.7	840.5	844.7	828.6	813.1	820.2	787.1	780.0
Discrepancy between UBA RA figures and UBA's figures	-0.2	-0.2	0.1	0.5	0.5	-0.3	0.0	0.4	0.4	0.5	0.6	0.7	0.6	1.9	1.4	1.4	1.6	0.2	-1.0
Sectoral approach, UBA (1.A)	977.3	943.9	897.9	889.3	870.6	869.3	891.8	860.7	853.9	828.1	827.2	849.1	835.4	828.8	817.4	802.3	807.5	785.3	787.8

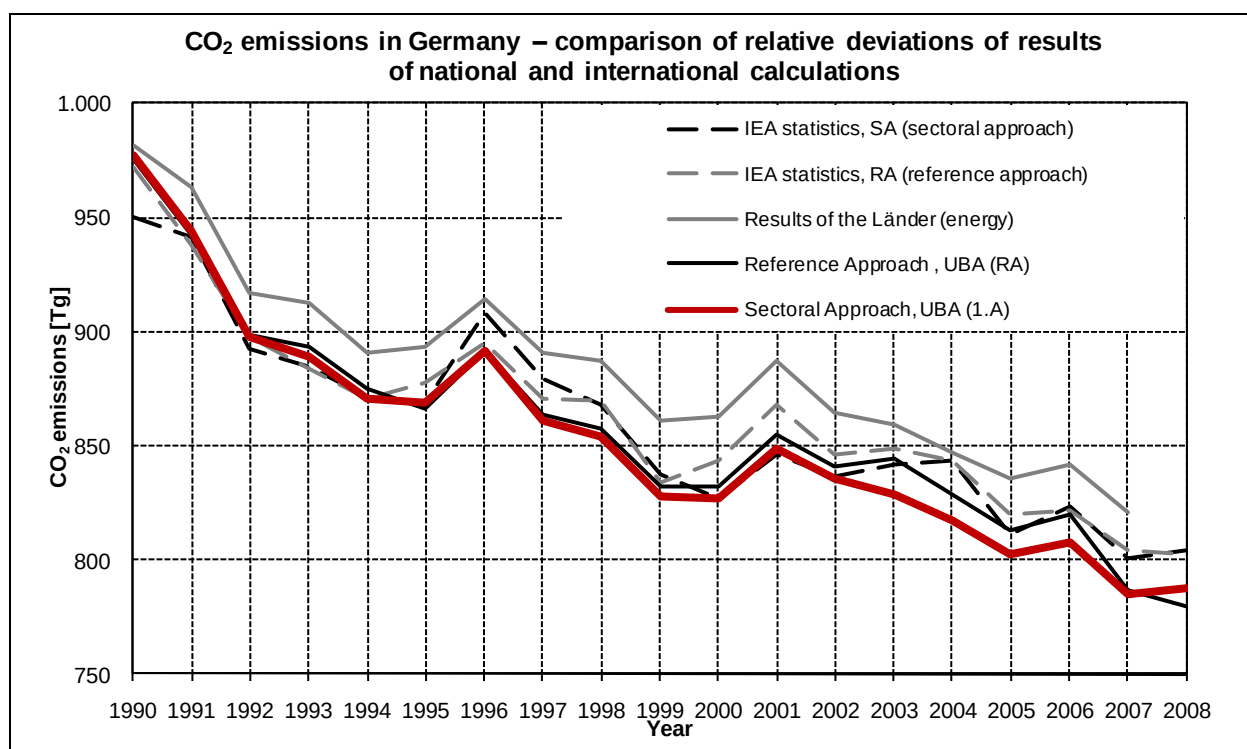


Figure 21: CO₂ emissions in Germany – comparison of results of national and international calculations

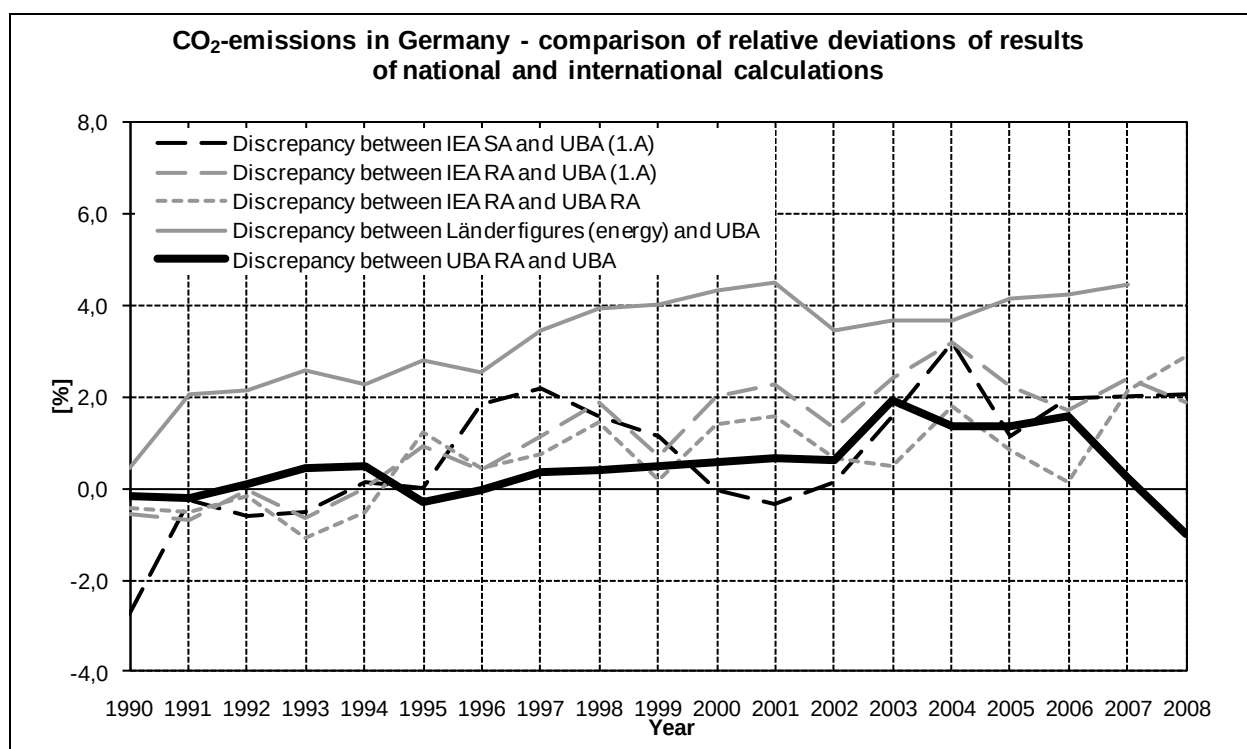


Figure 22: CO₂ emissions in Germany – comparison of relative discrepancies of national and international calculations

3.2.1.2.1 Comparison with the IEA results

Comparison with the IEA results was included here for reasons of completeness. Annually updated, internationally published data (most recently: OECD/IEA 2010) are available. The method of determining, processing and applying the basic data used for this purpose is not

precisely comparable with the national procedure in Germany at present, due to a lack of the necessary further methodological information – particularly information with regard to the detailed data used.

However, results of the comparison confirm the data obtained via the national, detailed method (mean deviation over 19 years: 0.8 %; fluctuation since 1990 ranges between -2.7 and 3.2 %).

The results of the Reference Approach used by the IEA differ from those of the reference approach carried out in Germany by 1.2 %, over a 19-year average.

3.2.1.2.2 *Comparison with the data obtained for the individual Länder*

The German Länder publish data on their own CO₂ emissions (cf.: http://www.lak-energiebilanzen.de/sixcms/detail.php?template=liste_cobilanzen). Regarding the relevant procedures, responsible institutions and methodological descriptions, we also call the reader's attention to that Web site and to the pertinent more detailed remarks in the NIR 2009.

The following section presents a comparison, for energy-related CO₂ emissions, of a) Länder results published to date in the Balance of Emissions Causes (BEU) and b) inventories calculated at the national level. One difficulty hampering the comparison, which is based on data for the years 1990 to 2007, is that pertinent information is not always available in the form of complete time series for the individual Länder for all relevant years. Suitable procedures for closing the resulting gaps were used. For the most part, those procedures are based largely on interpolation. For two Länder, they are based on extrapolation for the year 2007. The following section presents a compilation of the relevant data and results used. For reasons tied to the manner in which the data were obtained, as explained above, the data and results should be seen only as an orientation.

Table 22: Comparison of the results of CO₂ calculations of individual Länder with corresponding figures from the federal inventories

Land (state)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Gg CO₂																	
Baden-Württemberg	74374	78590	78036	78673	74535	78074	81759	78570	80080	77379	74940	80108	76549	75598	74768	77222	78283	70952
Bavaria	84544	88972	87041	90335	87871	88307	92265	89837	92708	90590	88705	90377	84578	83783	83190	80541	81879	74972
Berlin	26941	27957	25234	26643	25531	24445	24726	23560	22876	23693	23661	24068	21281	21249	20184	19998	19915	17466
Brandenburg	81894	66751	58894	57104	54011	50791	50312	50762	59255	57784	60564	60928	61537	57910	58882	59910	58273	58173
Bremen	13433	13586	12903	12517	13341	13239	14256	14170	13857	12793	14079	14137	14031	14667	13057	12222	12704	13645
Hamburg	12743	14226	13116	13813	13361	13467	14572	13940	13.651	13.362	13.073	12.784	12.495	12206	11589	11343	11451	10940
Hesse	50338	53945	53267	56060	56201	56126	59935	57264	57156	54688	56011	57817	54897	55528	54787	54441	53170	52627
Mecklenburg – West Pomerania	15539	10757	9360	9473	9510	10233	11636	10654	10413	10627	10256	10718	10908	10451	10961	10511	11080	10081
Lower Saxony	77138	82276	80.915	79.553	78.192	78.334	78.475	79.440	80.405	77.316	74.228	73.145	72.061	71.040	70.019	70.158	70.298	69.898
North Rhine – Westphalia	299028	309888	306287	300041	295874	303349	312345	307064	304784	294014	293987	299969	295293	295885	291555	282533	287140	289557
Rhineland-Palatinate	27394	29448	28914	30248	30274	31490	31463	31646	31167	30311	28853	29574	27793	26787	26432	26399	27110	25596
Saarland	23708	25767	24398	23214	24313	23133	23852	21825	23795	22833	23459	23260	22964	23278	23917	24799	23577	25714
Saxony	91465	77105	64059	66046	62988	61349	56223	51036	37167	35116	41552	48842	49038	49625	48476	47019	48295	46854
Saxony-Anhalt	50863	38085	31892	27887	26307	25200	25652	25294	25261	26900	26301	26840	27518	28171	27145	27846	27821	26477
Schleswig-Holstein	24200	23826	24082	24590	24191	22940	23517	22654	22426	21868	21378	22737	21455	21401	20592	19356	19339	17032
Thuringia	28098	22071	18687	16334	13992	13240	13641	12806	12713	12438	12059	12339	12066	11924	11812	11450	11283	10422
Total	981699	963249	917084	912531	890493	893716	914629	890521	887713	861712	863106	887643	864465	859503	847366	835749	841617	820404
Result for the nation as a whole	977264	943947	897852	889289	870588	869291	891752	860677	853907	828055	827226	849089	835355	828821	817411	802254	807491	785265
Deviation (Gg)	4435	19302	19232	23242	19906	24425	22877	29845	33806	33657	35880	38554	29110	30682	29955	33494	34126	35140
Deviation (%)	0.5	2.0	2.1	2.6	2.3	2.8	2.6	3.5	4.0	4.1	4.3	4.5	3.5	3.7	3.7	4.2	4.2	4.5

Remark: The figures in italics are not part of consistent time series and were generated via gap-closure procedures (see text).

In terms of trend, the comparison found excellent agreement between the combined Länder results and the Federal inventory. On an average for the 19 years in question, the total CO₂ emissions for the Länder were 3.1 % higher than the Federal result. The extremes of the deviations ranged from 0.5 % in 1990 to 4.5 % in 2007.

3.2.1.2.3 Planned improvements

Following the reporting process, the results of the comparison are discussed, regularly and intensively, and reviewed with regard to potential for improvement, with the representatives of the Länder Working Group on Energy Balances (Länderarbeitskreis Energiebilanzen). At present, no concrete plans for further improvements are in place.

In future, CO₂ verification is to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from emissions calculation (primarily, activity data) are to be compared more closely with aggregated data from emissions trading.

3.2.2 International bunker fuels

3.2.2.1 Emissions from international transports (1.C.1.a/1.C.1.b)

The area of international transports is divided into international civil air transports (1.C.1.a) and international sea transports (1.C.1.b), the latter of which also includes blue-water fisheries and maritime navigation.

3.2.2.2 Emissions from international air transports (1.C.1.a)

3.2.2.2.1 Source category description (1.C.1.a)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	-	-	-	CS	CS	CS	CS	CS
EF uncertainties in %	±5	-57 +100				-70 +150				
Distribution of uncertainties	N	L				L				
EF-determination method	T2	T3				T3				

Source category 1.C.1.a "International civil aviation", which is part of the relevant reported source category, is not included in key-source analysis.

Emissions from fuel consumption for international air transports are included in inventory calculation; however, in agreement with the IPCC Good Practice Guidance (IPCC, 2000: p. 2.57) they are not reported as part of national total inventories.

International air traffic from German airports has been growing continually, in both relative and absolute terms. That trend has gone hand-in-hand with a similar trend in the area of greenhouse-gas emissions, as shown in the following figure.

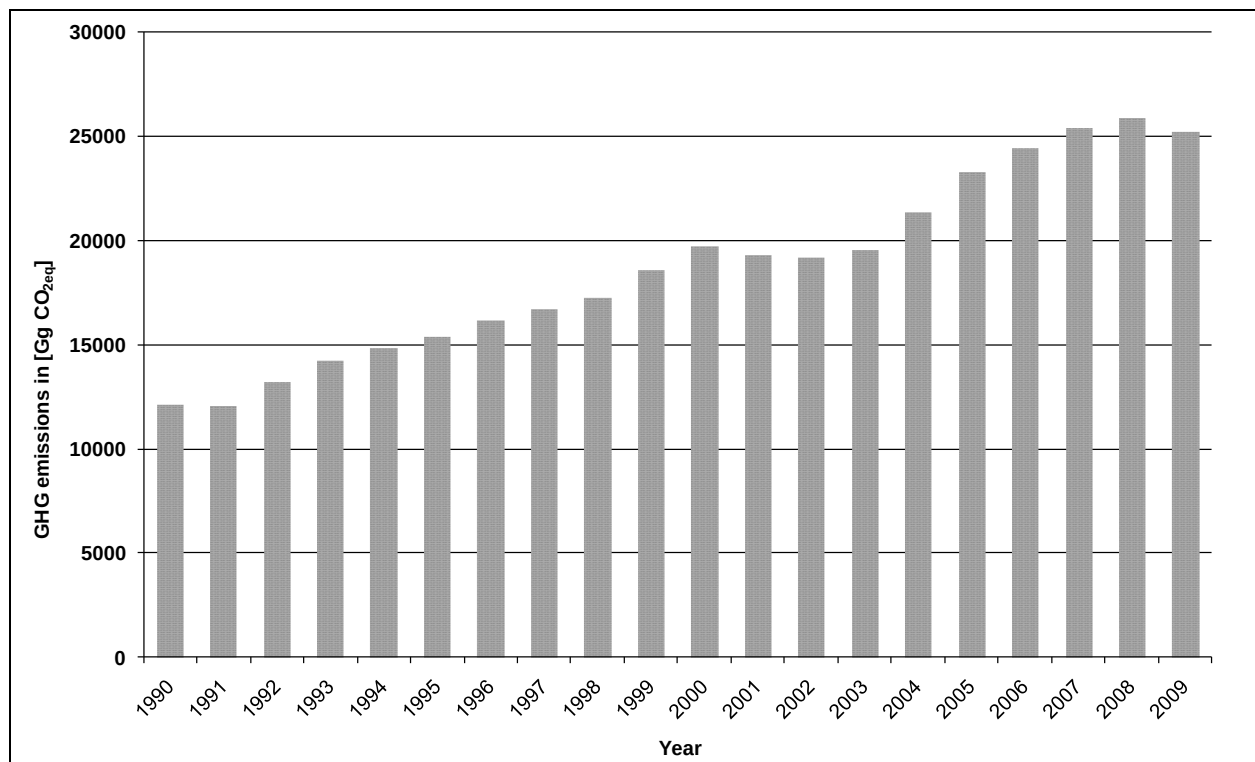


Figure 23: Development of greenhouse-gas emissions of international air traffic departing from Germany, 1990 - 2009

3.2.2.2 Methodological issues (1.C.1.a)

German energy statistics do not yet provide an official breakdown of fuel consumption relative to international air-transport emissions. To permit differentiation by national and international consumption nevertheless, these fuel-consumption figures are broken down by domestic and international air transports.

Currently, this breakdown is made in accordance with an annual split factor that refers to domestic air transports' share of total kerosene consumption. For 1990, a figure of about 15 %, based on individual movements of aircraft, was obtained via a research project. For years as of 2003, the relevant figure is provided directly by Eurocontrol (which calculates in accordance with Tier 3). For the years 1991 through 2002, interpolation is carried out via a continuous change function that is based on aircraft-movement data.

International air transports' so-determined shares of the kerosene consumption figures listed in the Energy Balance (AGEB) and in the official mineral-oil data (Amtliche Mineralöl-daten) of the Federal Office of Economics and Export Control (BAFA) (AGEB, 2010; BAFA, 2010), are as follows:

Table 23: Development of international air transports' share of total kerosene consumption, since 1990

Year	1990	1995	2000	2005	2006	2007	2008	2009
Share of total [%]	84.9	89.2	89.7	91.7	91.6	91.8	92.1	92.3

Avgas consumption is reported separately, and solely for domestic air transports. It does not enter into calculation of the split factor.

International civil aviation is separately listed as such in the CSE.

Additional information relative to the activity data and emission factors used is presented in Chapter 3.2.10.1 on national civil air transports.

3.2.2.2.3 *Uncertainties and time-series consistency (1.C.1.a)*

Cf. National air transport, Chapter 3.2.10.1.3.

3.2.2.2.4 *Source-specific quality assurance / control (1.C.1.a)*

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The Single National Entity's additional quality assurance remains to be carried out.

For details, cf. National air transport, Chapter 3.2.10.3.4.

3.2.2.2.5 *Source-specific recalculations (1.C.1.a)*

Comprehensive recalculations were carried out for the years 1990 through 2002, on the basis of findings from a research project showing that international air transports' share of total kerosene consumption has increased from 80 % (the last relevant figure used), in 1990, to about 85 % at present.

In addition, total kerosene consumption for the years 2004 and 2008 was corrected in accordance with the statistics used.

Table 24: Changes in international air transports' share of total kerosene consumption, 1990-2008

Reported in	Units	1990	1991	1992	1993	1994	1995	1996
Resubmission 2010	[%]	80.00	81.12	82.18	83.18	84.12	85.01	85.85
Submission 2011		84.89	85.93	87.46	88.67	89.05	89.21	89.25
Absolute difference		4.89	4.81	5.28	5.50	4.93	4.20	3.40
Relative difference		6.11	5.93	6.42	6.61	5.86	4.94	3.96
Reported in	Units	1997	1998	1999	2000	2001	2002	2003
Resubmission 2010	[%]	86.64	87.39	88.09	88.76	89.39	89.98	90.54
Submission 2011		88.88	89.20	89.65	89.68	89.98	90.25	90.54
Absolute difference		2.24	1.81	1.56	0.92	0.59	0.27	0.00
Relative difference		2.59	2.07	1.77	1.03	0.66	0.30	0.00

Table 25: Effects of the described recalculations on emissions in source category 1.C.1.a – International air transports, 1990-2008

Reported in	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Resubmission 2010	[Gg CO ₂ -equiv.]	11,523	11,457	12,511	13,324	14,010	14,680	15,535	16,268	16,884	18,262
Submission 2011		12,140	12,053	13,223	14,205	14,832	15,405	16,150	16,691	17,235	18,586
Absolute difference		617.5	596.0	712.4	880.9	821.8	724.9	614.4	422.6	350.6	323.7
Relative difference		5.36	5.20	5.69	6.61	5.87	4.94	3.96	2.60	2.08	1.77
Reported in	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Resubmission 2010	[Gg CO ₂ -equiv.]	19,518	19,162	19,132	19,547	20,198	23,314	24,473	25,431	25,777	-
Submission 2011		19,720	19,289	19,187	19,547	21,377	23,314	24,473	25,431	25,898	25,204
Absolute difference		201.9	126.9	55.5	0.1	1,178.6	0.2	0.2	0.2	120.7	-
Relative difference		1.03	0.66	0.29	0.0007	5.84	0.0008	0.0007	0.0007	0.47	-

The further impacts on the overall inventory are described in detail in Chapter 3.2.10.1.5.

3.2.2.2.6 *Planned improvements (1.C.1.a)*

Cf. National air transport, Chapter 3.2.10.1.6.

3.2.2.3 Emissions from international maritime transport / maritime navigation (1.C.1.b)

3.2.2.3.1 *Source category description (1.C.1.b)*

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	D	--	--	--	D	D	D	D	D
EF uncertainties in %	±5	-57 +100	--	--	--	-70 +150				
Distribution of uncertainties	N	L	--	--	--	L				
EF-determination method	T1	T1	--	--	--	T1				

Source category 1.C.1.b "International maritime transport / maritime navigation", which is part of the relevant reported source category, is not included in key-source analysis.

International maritime transports includes both maritime shipping and blue-water fisheries. In the present report, fuel consumption and emissions of German blue-water fisheries have been deducted, for the first time, from international maritime transports and, in accordance with the IPCC's requirements, reported as part of the national overall inventory under 1.A.4.c (iii) - Fisheries. (cf. the source-category-specific recalculations below, and Chapter 3.2.11).

Emissions from fuel consumption for international transports of ocean-going ships are included in the inventory calculation although, in keeping with the UNFCCC guidelines, they are not reported as part of total national inventories.

Consumption of heavy oil has been increasing since 1984, as a result of high petroleum prices and of increasing maritime use of diesel engines that can run on heavy oil.

Temporary emissions reductions, especially those that occurred in 1992 and 2009, have been / were caused by trade and oil crises.

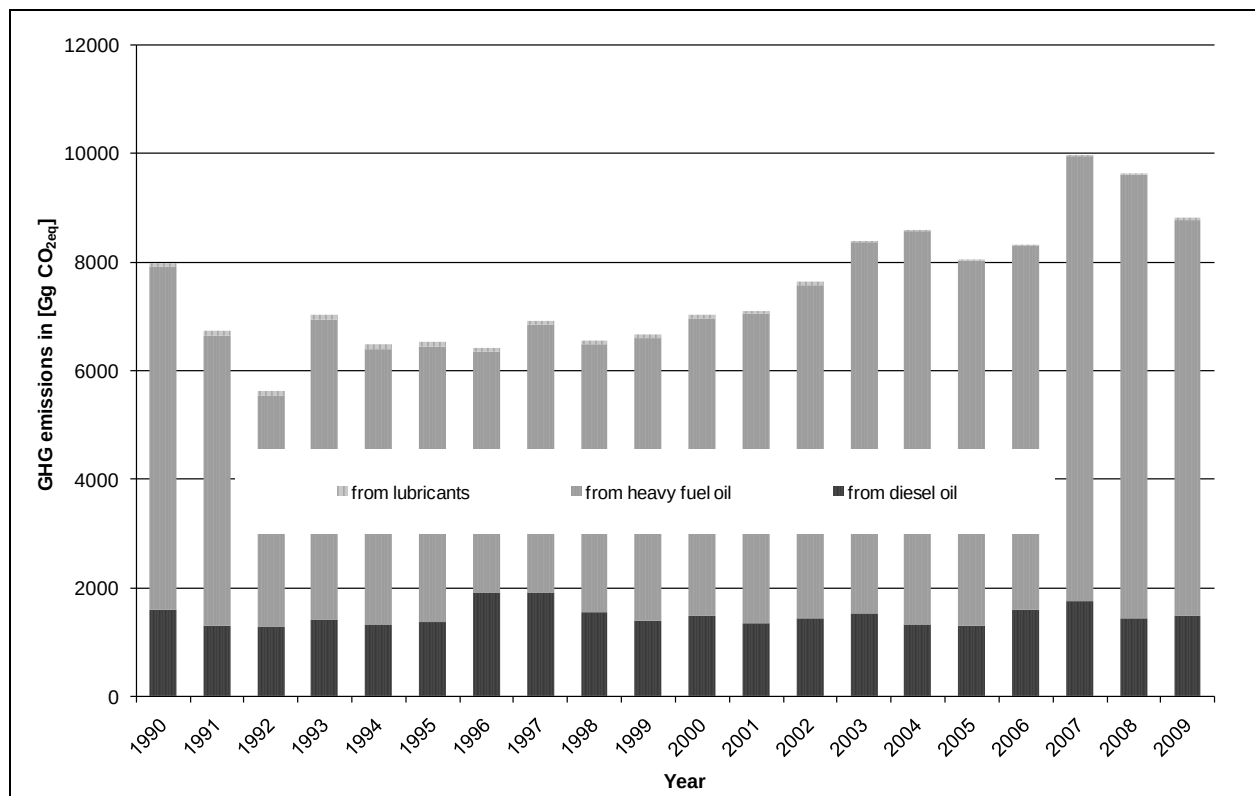


Figure 24: Development of greenhouse-gas emissions in international maritime transports, 1990 – 2009

3.2.2.3.2 Methodological issues (1.C.1.b)

Germany reports in keeping with the Tier 1 method. Emissions are calculated as the product of consumed fuels and country-specific emission factors for CO₂ and default EF for CH₄ and N₂O.

As a rule, the **activity data** for bunkering in ocean-going ships are taken from the Energy Balances of the Federal Republic of Germany (AGEB, 2010). The reason why these rates are listed separately is that fuel purchased in ports is taxed differently.

Table 26 Activity data taken from the Energy Balance (1.C.1.b)

Fuel	Energy Balance line	Relevant years
Diesel fuel	6 – High-seas bunkering	since 1990
Heating oil, heavy		

For years for which no Energy Balance is yet available, data of the Federal Office of Economics and Export Control (BAFA) are used as a basis. These data are published as "Amtliche Mineralöl-daten für die Bundesrepublik Deutschland" ("Official mineral-oil data for the Federal Republic of Germany"; for the present context: Table 6j, column: "Bunker int. Schifffahrt" ("bunkering, international shipping") (BAFA, 2010).

Beginning with the Resubmission 2010, a conservatively calculated share of these statistically recorded quantities is allotted to German deep sea fishing and, thus, reported under 1.A.4.c iii – Other sectors: fisheries as part of the national inventory (cf. Chapter 3.2.11).

For calculation of N₂O, CH₄, CO, NO_x and NMVOC emissions, default **emission factors** from the Revised 1996 IPCC Guidelines (Reference Manual, 1996b: p.1.90 Table 1-48) are used.

With regard to the CO₂ emission factor for diesel fuel, 74,000 kg/TJ, and to that for heavy heating oil, 78,000 kg/TJ, the reader's attention is called to the documentation in Annex 2, Chapter 18.6.

3.2.2.3.3 *Uncertainties and time-series consistency (1.C.1.b)*

Since the emission factor for CO₂ is a calculatable value that depends solely on fuel composition, the uncertainty for that emission factor is considered to be very low. It is set here at ±5 %. The same low uncertainty is assumed for the emission factors used for CO₂. On the other hand, default uncertainties of the IPCC are used for the emission factors for methane and nitrous oxide.

3.2.2.3.4 *Source-specific quality assurance / control and verification (1.C.1.b)*

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The Single National Entity's additional quality assurance remains to be carried out.

Source-specific verification of the emission factors for CO₂, methane and nitrous oxide was carried out via comparison with the pertinent factors used by other nations.

Due to a lack of relevant additional national and international sources (such as EU-ETS), it was not possible to compare activity data and emissions for this area.

3.2.2.3.5 *Source-specific recalculation (1.C.1.b)*

No recalculations have been carried out with respect to the data provided in the Resubmission 2010.

The changes made in the Resubmission, with respect to the Submission 2010, are described in detail in Chapter 10.5. The methods described in that section, for separate determination of activity data and emissions of German blue-water fisheries, are also used in the present report.

3.2.2.3.6 *Planned improvements (1.C.1.b)*

In the framework of a study, ship-movement data are currently being determined via the Automatic Identification System (AIS; a radio-based and satellite-based system for transmission of ship data such as size, load, speed, route, etc.). The resulting bunkering-quantities data will then be used, in combination with also-updated specific emission factors, for description of the emissions to be assigned to Germany.

3.2.3 *Storage*

In a research project carried out in co-operation with the University of Utrecht (UU STS, 2007), emissions from non-energy-related use of industrially used fuels were calculated for the first time for the years between 1990 and 2004 and then compared with the figures used for the CO₂ reference procedure. The pertinent results are summarised in Annex 2, Chapter 13.9 of the NIR 2007.

3.2.4 CO₂ capture and storage (CCS)

At present, CO₂ capture and storage (CCS) technology is still in the research phase in Deutschland; some pilot systems are in place. Currently, storage via CCS is not included in the German inventory.

3.2.5 Special country-specific aspects

There are no special aspects that would influence reporting.

3.2.6 Public electricity and heat production (1.A.1.a)

3.2.6.1 Source category description (1.A.1.a)

CRF 1.A.1.a					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	l / t / T2	CO ₂	27.76 %	32.52 %	-10.0 %
All Fuels	l / - / T2	N ₂ O	0.30 %	0.36 %	-6.6 %
All Fuels	- / t / T2	CH ₄	0.02 %	0.17 %	+774.0 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 3	+/-50	-	-	-	+/-50				
Distribution of uncertainties	T	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

Remark: See the "Declaration regarding introductory information tables", at the beginning of the NIR, for further information about these tables.

The source category *Public electricity and heat production* is a key source of CO₂ emissions in terms of level and trend. For N₂O emissions, it is a key source only in terms of level, and for CH₄ emissions, it is a key source only in terms of trend.

Under source category 1.A.1.a, "Public electricity and heat production", the CSE includes district heating stations and electricity and heat production of public power stations. Plants that feed electricity produced from biomass into the public grid are also assigned to source category 1.A.1.a.

Some 100 GW of net bottleneck capacity were in place in the public electricity generating sector in 2009. Of this amount, about 68 GW were operated with fossil fuels or with transformation products of fossil fuels. As a group, all fossil-driven plants generated some 308 TWh of electrical work. This corresponds to about 64 % of all public electricity generation (about 479 TWh). About 243 TWh of electricity were generated solely with lignite and hard coal (FEDERAL STATISTICAL OFFICE, 2009a).

In 2009, thermal power stations contributed net electricity production of 50 TWh, and net heat production of 109 TWh, to the public energy supply. The district-heat supply is supplemented with heat, amounting to 22 TWh, from heat-only boiler stations that are normally run in peak-load operation.

The following figure presents an overview of development of CO₂ emissions in source category 1.A.1.a:

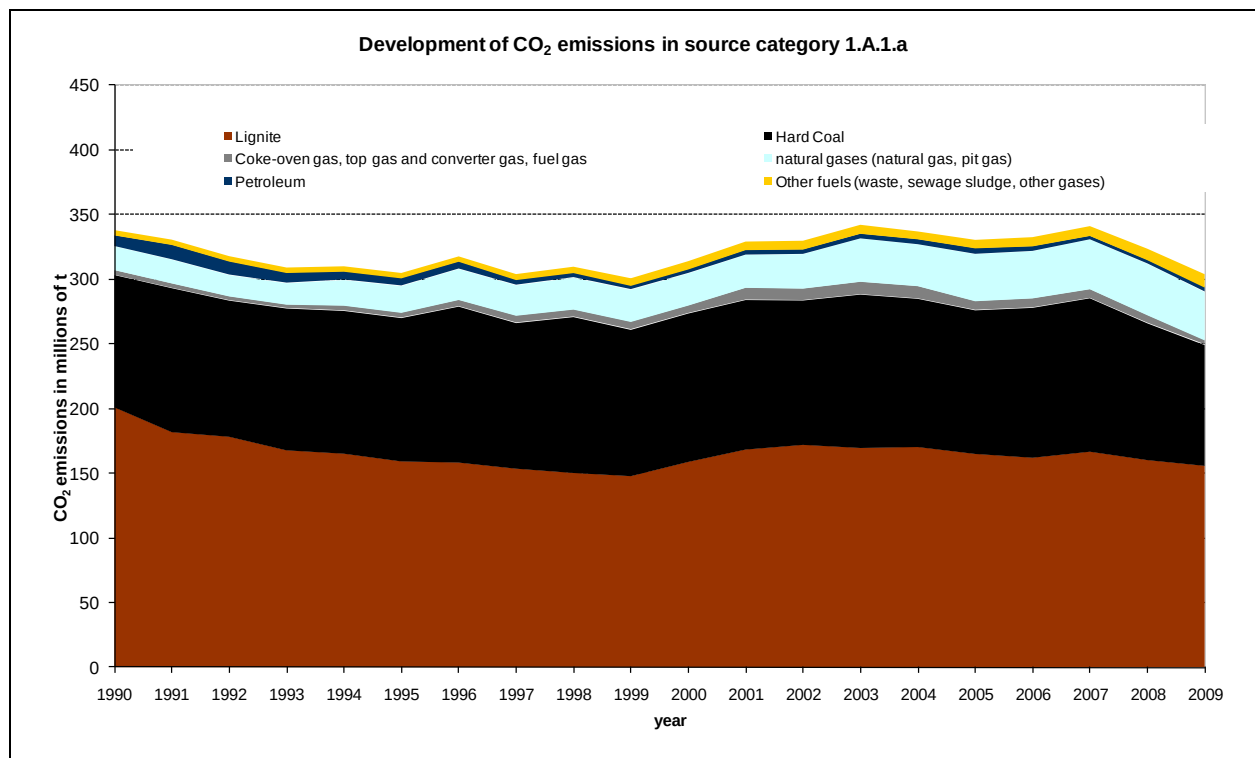


Figure 25: Development of CO₂ emissions in source category 1.A.1.a

Overall, emissions until 1999 show a falling trend, due primarily to closure of four lignite-fired installations in the new German Länder. Thereafter, a number of installations were replaced. As of 2000, then, the newly installed capacities, in the category of lignite-fired power stations, exceeded those of the decommissioned power stations, and thus emissions began increasing again. Nonetheless, overall emissions from lignite-based electricity generation are considerably below the corresponding emissions level in 1990.

In the main, the emissions trend is shaped by the development and structures of the electricity generation installations involved, since those installations account for the majority of the pertinent emissions. From 1990 through 1993, electricity consumption decreased, as a result of the collapse of industry in the new German Länder. From 1994 until 2007, a marked increase in electricity consumption occurred in all sectors, sparking increases in electricity production. As a result, emissions from electricity production also increased. In addition, electricity exports increased. Those exports begin showing up in the overall balance as of 2003. The increasing trend has been tempered by increased use of natural gas, by improvements in power stations' efficiency and by increasing electricity generation via renewable energies.

In 2007, particularly large quantities of coal were used for electricity generation, in keeping with low prices for emissions certificates. Thereafter, beginning as early as 2008, a marked emissions decrease occurred, as a result of increase use of nuclear power, natural gas and renewable energies. In 2009, the financial and economic crisis occurred, also affecting the public energy supply. In particular, hard-coal-fired power stations, which are used in the medium-load range, produced considerably less electricity, thereby also producing considerably lower emissions. With that trend, emissions from hard-coal-fired electricity generation dropped below the 1990 level, for the first time since that year. As seen via the relevant time series, hard-coal-fired power stations show higher fluctuations in fuel inputs than lignite-fired power stations do. The reason is that they, in contrast to lignite-fired power

stations, are operated primarily in the medium-load range, where they respond more markedly to fluctuations in demand. What is more, they are dependent on import prices. Furthermore, as of the mid-1990s sectoral shifting occurred, from industry (1.A.1.c and 1.A.2.f) to the public electricity supply (1.A.1.a), as more and more operators reported their data in the public electricity supply category.

Petroleum plays only a minor role in Germany's electricity supply. It is used primarily for auxiliary and supplementary firing in coal-fired and waste-to-energy power stations, as well as for peak-load generation. Use of petroleum in these roles has dropped by more than half since 1990. In the crisis year 2009, when petroleum became considerably cheaper than natural gas, use of petroleum for peak-load generation increased again somewhat.

Use of natural gas for electricity generation has increased markedly since 1990. That trend has not led to an equivalent emissions increase, however, since the specific CO₂ emissions of natural gas are considerably lower than those of coal. The significant increase in natural gas use seen since 2005 is due especially to the commissioning of a considerable number of major gas and steam turbine power stations and medium-sized gas-turbine power stations. What is more, natural gas is increasingly being used as balancing energy for electricity generation with fluctuating renewable energies. Since 1990, waste inputs in waste-incineration plants and for co-incineration have also been increasing, as a result of changes in relevant laws. While increased use of waste in this area produces additional emissions, it helps prevent methane emissions from landfills. Use of industrial gases for electricity generation depends on production, as the crisis year 2009 showed. In addition, the relevant figures depend on whether operators, in the context of statistical surveys, report their use in the "industry" category or "public electricity supply" category. Overall, changes in sectoral classification repeatedly occur in connection with all fuels.

3.2.6.2 Methodological issues (1.A.1.a)

Activity data

The calculation method has been selected on the basis of current key-source analysis, and it conforms to the decision tree in the IPCC Good Practice Guidance.

The fuel input for public electricity production is given in line 11 ("Public thermal power stations") of the Energy Balance. The fuel inputs for public heat production are given in lines 15 ("thermal power stations") and 16 ("district heating stations").

In the "Balance of Emissions Causes" model, the energy inputs listed in the Energy Balance are divided among several time series, with the help of statistical data. The aim of the calculations is to produce a database that is adjusted to the special technical characteristics of electricity and heat production. As a result, fuel-specific and technology-specific emission factors can be applied to the relevant activity data.

For the 2006 report, the activity data for the new German Länder for the year 1990 were revised and substantiated in the framework of a research project (FKZ 205 41 115 / sub-project A, "Revision and Documentation of Fuel Inputs for Stationary Combustion System in the new German Länder for the year 1990").

In the case of electricity and heat production in waste-incineration systems of public power stations, and of heat production in waste-incineration systems of public district heating stations, both energy statistics and the Energy Balance have shown considerably smaller

relevant waste quantities than have the waste statistics of the Federal Statistical Office (*FEDERAL STATISTICAL OFFICE*, FS 19 Reihe (series) 1). In the interest of including relevant fuel inputs as completely as possible, the relevant fuel inputs in the Energy Balance were supplemented with the pertinent difference between the Energy Balance and the waste statistics. As of 2005, energy statistics show a considerable increase in waste inputs. In 2006, then, the waste quantities shown in the Energy Balance increased to a degree that made it possible to discontinue use of additional data from waste statistics. Considerably improved data, with significantly more finely differentiated fuel information based on surveys of the Federal Statistical Office, made it possible to separate out figures for solid biomass (especially waste and scrap wood), biogenic gases, sewage sludge and waste heat. In addition, it became possible to list co-incineration of waste and sewage sludge separately. Revision of fuel inputs for waste incineration and co-incineration has not yet been completed. In a next step, classification of fuels in the sectors public electricity generation (1.A.1.a) mining (1.A.1.c) and manufacturing (1.A.2) is to be reviewed. Suitable, differentiated, sector-specific waste-statistics data for that purpose are already available and await close evaluation.

s of the NIR 2006, the fossil and biogenic fractions of household / municipal waste are listed separately, in a ratio of 1/1. The existing assumptions regarding the biogenic fractions of sewage sludge and industrial waste (a new fuel category that appeared in energy statistics for the first time in 2008) need to be reviewed.

The activity data for other fuels are taken directly from the Energy Balance. Where pertinent statistical indications or experts' assessments are available, fuel inputs are additionally divided into two size classes (combustion systems smaller and larger than 50 MW). The dividing line between these two categories is based on legal regulations pertaining to licensing of combustion systems in the Federal Republic of Germany.

As of the NIR 2011, CO₂ emissions from top-gas combustion in public power stations are reported in source category 1.A.1.a. The following table provides an overview of relevant emissions from top-gas use, for the entire time series since 1990.

Table 27: CO₂ emissions from top-gas combustion in public power stations

[millions of t of CO ₂)									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3.236	3.283	3.008	2.719	3.744	3.745	4.796	5.282	5.440	5.782
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5.930	9.243	8.990	9.723	9.597	6.866	7.112	6.578	5.858	3.300

Emission factors (except for CO₂- emission factors)

The underlying data for the emission factors used is provided by the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" ("Determination and evaluation of emission factors for combustion plants in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002). The values for the intermediate years 1996 - 1999 and 2001 - 2009 are obtained via linear interpolation. That project, along with the linear interpolation for the intermediate years, has also provided the underlying data for the emission factors presented in Chapters 3.2.7, 3.2.8, 3.2.9.6 and 3.2.10.5, where the factors include power stations, gas turbines or boilers for generation of steam and hot/warm water. The research project was carried out by the Franco-German Institute for Environmental Research (Deutsch-Französisches Institut für

Umweltforschung – DFIU) at the University of Karlsruhe, and it was completed at the end of 2002. The project aim was to determine and evaluate representative emission factors for the main air pollutants produced by combustion systems in Germany that are subject to licensing requirements, and to do so for the years 1995, 2000 and 2010. This process consists primarily of analysing and characterising the relevant emitter structures, and the pertinent emission factors, for the year 1995, and then of updating the data for the years 2000 and 2010. This procedure systematically determines emission factors for the substances SO₂, NO_x, CO, NMVOC, dust and N₂O. The process differentiates between 12 coal fuels, 4 liquid fuels, 7 gaseous fuels and firewood. In addition, the available data relative to emission factors of other substances are also compiled; these other substances include PAH, PCDD/F, As and Cd for combustion systems subject to licensing requirements, and CH₄ for gas turbines and combustion systems under the TA Luft that are subject to licensing requirements. Annex 3 (Chapter 19.1.2) discusses the procedure used in the research project.

As part of a research project, completed in February 2007, for updating the National Programme in the framework of Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants ("NEC Directive"), individual emission factors for the components SO₂, NO_x and dust were revised in keeping with recent findings. No changes were made in the climate-relevant components N₂O and CH₄, however (research project "Measures for compliance with the emission ceilings of the NEC Directive", FKZ 205 42 221; final report of the sub-project "Reference scenario 2000 – 2020 for emissions under the NEC Directive (SO₂, NO_x, NMVOC, NH₃)" of October 2006).

For this reporting round, for the first time ever and in the framework of a research project carried out by the Institute for Future Studies and Technology Assessment (IZT), "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV" ("Processing of data in emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act"), special CH₄ emission factors for gas engines were determined. The average value for natural gas as a fuel, 309 kg/TJ, is markedly higher than the previously assumed value, 0.3 kg/TJ, which is approximately the same as the value for steam-turbine power stations. With emissions-monitoring data, it was possible to confirm that significant methane leakage occurs via leakage of unburned natural gas. The pertinent measurements can vary considerably, in keeping with the type of engine and engine-maintenance standards involved. For biogas, sewage gas, landfill gas and mine gas, an average CH₄ emission factor of 185 kg/TJ was determined. For biogas, at least, it was possible to confirm that figure with data from emissions monitoring. In light of the lower methane concentrations of biogenic gases, the corresponding factor must be set lower for them than for natural gas.

In Germany, N₂O is monitored only in exceptional cases; for this reason, no relevant data from regular measurements are available. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, especially in fluidised-bed combustion, has been specifically studied, especially in the 1990s. For this reason, enough measurement data were available to permit systematic survey of N₂O emission factors in the research project. The relevant technological emission factors for large combustion plants, as determined in the research project, are summarised in Table 28. Those factors were used as a basis for calculating the source-category-specific emission factors for the CSE.

Table 28: Technological emission factors for nitrous oxide from large combustion systems

Fuel / combustion technology	N ₂ O emission factor (1995 - 2010) [kg/TJ]
Hard coal / fluidised bed	20
Hard coal / other combustion methods	4
Lignite / fluidised bed	8
Lignite / dry-dust combustion, in the new Länder	3.2
Lignite / other combustion methods	3.5
Liquid fuels	1
Gaseous fuels	0.5

The data presented in Table 29, taken from the research project RENTZ et al (2002), served as the basis for systems < 50 MW furnace thermal output. The relevant median figures are shown in brackets.

Table 29: Technological emission factors for nitrous oxide from systems < 50 MW furnace thermal output

Fuel	Technology	Output	Länder	N ₂ O-E factor / median [kg/TJ]
Hard coal (Steinkohle)	Grate combustion	< 5 MW	/	2.5 - 5.2 [3.9]
		≥ 5 MW	ABL	2.5 - 5.2 [3.9]
		≥ 5 MW	NBL	2.5 - 5.2 [3.9]
	Furnace-shell combustion	< 5 MW	ABL	2.5 - 5.2 [3.9]
		< 5 MW	NBL	2.5 - 5.2 [3.9]
		≥ 5 MW	/	2.5 - 5.2 [3.9]
	Fluidised-bed combustion	< 5 MW	/	25 - 40 [36]
		≥ 5 MW	/	2 - 170 [47]
Lignite (Braunkohle)	- dust	Dust combustion	≥ 5 MW	NBL [3.2]
	- briquette	n.i.	< 5 MW	NBL 0.4 - 3.7 [2.1]
	Raw	n.i.	< 5 MW	NBL 0.4 - 3.7 [2.1]
			≥ 5 MW	ABL 0.4 - 3.7 [2.1]
			≥ 5 MW	NBL 0.4 - 3.7 [2.1]
		Fluidised-bed combustion	≥ 5 MW	/ 40 - 50 [45]
	Heavy heating oil	n.i.	/	ABL 2 - 4 [3]
			/	NBL 2 - 4 [3]
Light heating oil	n.i.	≥ 20 MW	/	0.6 - 1.5 [1.1]
Natural gas	n.i.	≥ 10 MW	/	0.3 - 1.5 [0.9]

n.i. not included

ABL Old German Länder

NBL New German Länder

Information on process-related CO₂ emissions from flue-gas scrubbing (flue-gas desulphurisation) in large combustion systems is provided by Annex 3 in Chapter 19.1.2.3.

3.2.6.3 Uncertainties and time-series consistency (1.A.1.a)

Uncertainties for activity data were determined, for the first time ever, for the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

The figures for the uncertainty of the CO₂ emission factor, and for the statistical distribution function for that uncertainty, have been estimated by the Federal Environment Agency. The

figures are based on the range covered by the carbon contents of the various individual fuels.

Other aspects relative to time-series consistency of activity data are explained in Chapter 18.4 and Chapter 18.5.

The uncertainty of the determined emission factors has been evaluated in the framework of the DFIU research project described in Chapter 3.2.6.2 and in Annex 3, Chapter 19.1.2.1.

3.2.6.3.1 Methods for determining uncertainties of emission factors

The uncertainties in emissions data result from several different factors. These include *precision*, which is influenced by chance and systematic errors in the framework of emission measurement, and completeness of the database with regard to available measurements. Another factor consists of *variability* of emissions. In this area, a distinction must be made between variability in emissions of a single plant, within the period in question (*intra-plant variability*) and differences between the emissions behaviours of the various sources considered (*inter-plant variability*).

Other sources of possible uncertainties can affect calculation of emissions with the help of emission factors. In the framework of IPCC-GPG (2000: Chapter 6), methods – adapted, in each case, to data availability – are proposed:

Where *continuous measurements* have been carried out, uncertainties should be characterised via direct determination of statistical indexes such as standard deviation and the 95%-confidence interval.

In determination of *plant-specific emission factors*, any available local measurements should be used. In addition, any special operational states (start-up and shut-down processes) and load changes should be taken account of, and available measurements should be reviewed for representativeness in light of the relevant plant's emissions behaviour.

In use of *emission factors from the literature*, all of the data-quality information provided by the sources in question should also be used. Furthermore, transferability should be reviewed – to what extent is the emission factor in question representative of the situation in the relevant area being studied? If the factor is not representative, an experts' assessment should be carried out.

In general, use of *experts' assessments* is recommended in cases in which available empirical data does not suffice for quantification. A sample explanation is provided in Annex 3, Chapter 14.1.2.2, of the NIR 2007.

3.2.6.3.2 Result for N₂O

Individual evaluations of the uncertainties in N₂O emission factors, carried out in the research project (RENTZ et al, 2002), are included in the Excel tables for transfer of emission factors into the Federal Environment Agency's CSE database; for power stations, the evaluations are also described in the final report. The great majority of values for relative uncertainty lie in the range between 0.6 and 0.9. As part of an experts' assessment, carried out by the research customer, pursuant to Tier 1 IPCC-GPG (2000: Chapter 6), an upper boundary of +/- 50 % was given for the percentage uncertainty in CRF category 1.A.1.a (as well as for categories 1.A.1.b, 1.A.1.c and 1.A.2.f / all other) (remark: values for +/- ranges must be

divided by 2; cf. IPCC-GPG (2000: Chapter 6, p. 6.14); in the process, uniform distribution of uncertainties was assumed – in keeping with the calculation method selected).

3.2.6.3.3 Result for CH₄

Combustion systems in Germany are not subject to monitoring of CH₄ emissions; for this reason, no systematic-measurement data are available in this area. Consequently, relevant individual data items available in Germany and Switzerland have been relied on. As a result of this database limitation, the research project did not attempt any systematic correlation with source categories treated by the project (cf. Chapter 3.2.6.2). The individual CH₄ emission factors, as determined in the research project (RENTZ et al, 2002), are summarised in Annex 19.1.2.2. Previously, the factors listed there, for hard coal fired in combustion systems < 50 MW (mean value for D: 3.35 kg/TJ), and for light heating oil and natural gas fired in gas turbines, were used in the CSE for the years as of 1995. Review and adoption of the project's remaining proposals are still pending. For these fuels, the existing emission factors in the CSE are used without change (solid fuels: 1.5 kg/TJ; liquid fuels: 3.5 kg/TJ; and gaseous fuels: 0.3 kg/TJ).

As part of an experts' assessment carried out by the research customer, pursuant to Tier 1 of the IPCC-GPG (2000: Chapter 6), an upper limit of +/- 50 % was estimated for the percentage uncertainty in source category 1.A.1.a (as well as in source categories 1.A.1.b, 1.A.1.c and 1.A.2f / all other); in the process, a uniform distribution of uncertainties was assumed – as was the case for N₂O.

3.2.6.3.4 Time-series consistency of emission factors

In the framework of the aforementioned research project (RENTZ et al 2002), the emission factors for N₂O were determined for 1995 (reference year) and then extrapolated, on that basis, for 2000 and 2010. With that approach, no changes result for most of these emission factors for the period from 1995 to 2009. The N₂O emission factors were forecast to decrease slightly only in the area of use of gas turbines (natural gas, light heating oil). This is a result of the higher mean gas-turbine-intake temperatures required in modern gas turbines in order to increase efficiency. These changes have no significant effect, however, on levels of total N₂O emissions in the CRF area under consideration.

The time series for N₂O between 1995 and 2009 were reviewed in this light and assessed as consistent overall. The time series of CH₄ emission factors for 1995 to 2009 were also reviewed and assessed as internally consistent.

In the NIR 2009, we reported on the period from 1990 to 1994.

To ensure time-series consistency, the CH₄ emission factors determined for combustion-engine systems were retroactively applied for the period back to 1990. Methane leakage is likely to have been higher in the early 1990s than it is with modern engine systems. Too little relevant measurement data is available for that period, however.

For most biogenic fuels, statistical fuel-input data are available only for the period since 2003. As a result, it is not possible to provide a consistent time series, for the period since 1990, for such fuels. That limitation affects only the trend for CH₄ emissions, which increases sharply as of the year 2003.

3.2.6.4 Source-specific quality assurance / control and verification (1.A.1.a)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet¹⁷.

Quality assurance for official statistics is carried out via an internal quality system. That system's quality reports are available for inspection within the Internet publications of the *Federal Statistical Office*.

In addition to these measures, regular exchanges and discussions are carried out with the members of the AGEB for purposes of clarifying data-collection issues and verifying data.

General measures for assuring the quality of emission factors for combustion plants, as used in the framework of a research project (RENTZ et al, 2002), are outlined in the methods description in Annex 3, Chapter 19.1.2.1 (after Figure 65). Their results were reported in the NIR 2005.

3.2.6.5 Source-specific recalculations (1.A.1.a)

For source category 1.A.1.a, changes, amounting to the amounts of the CO₂ emissions from top-gas use listed in Table ..., result for the entire time series.

In addition, the provisional figures for the year 2008 have now been replaced with now-available final statistics, leading to the following changes.

Solid fuels:	+ 1.994 million t CO ₂
Liquid fuels:	- 0.348 million t CO ₂
Gaseous fuels:	- 0.563 million t CO ₂
Waste-based fuels:	+ 1.188 million t CO ₂

3.2.6.6 Source-specific planned improvements (1.A.1.a)

In the framework of a major research project launched at the end of 2008, we have begun updating the database for emission factors (apart from those for CO₂) that is described in Chapter 3.2.6.2. Current plans call for the initial results from the project to enter into the 2012 NIR report. Parts of that project will address the N₂O-emissions behaviour of combustion and gas-turbine systems and the CH₄-emissions behaviour of gas-turbine systems.

In addition, plans call for further improvement of the methods for calculating activity data for waste incineration.

¹⁷ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63> (last checked on 30 October 2009)

3.2.7 Petroleum refining (1.A.1.b)

3.2.7.1 Source category description (1.A.1.b)

CRF 1.A.1.b					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	l / t / T2	CO ₂	1.64 %	2.16 %	+1.3 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 1	+/- 50	-	-	-	+/- 50				
Distribution of uncertainties	U	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

The source category *petroleum refining* is a key category for CO₂ emissions in terms of both emissions level and trend.

The figures given above apply for refinery power stations (part of source category 1.A.1.b).

The crude oil distillation capacity of German petroleum refineries totalled around 117.6 Mt in 2009. In that period, 100.7 Mt of crude oil, along with 12 Mt of intermediate products, were input for processing. Production of petroleum products totalled 110.8 Mt, of which about 57.4 Mt consisted of fuels, about 24.7 Mt consisted of heating oils, about 8 Mt consisted of naphtha and about 20.8 Mt consisted of other products. (MWV, 2010).

The refineries operate power stations with electrical output of about 0.9 GW. In 2009, these power stations generated 6.8 TWh of electrical work and yielded process heat for production purposes. (FEDERAL STATISTICAL OFFICE, 2009d).

Under source category 1.A.1.b, Petroleum refining, the CSE lists the sub-categories "refinery bottom-heating systems" and "electricity and heat production of refinery power stations".

The following figures provides an overview of emissions trends in source category 1.A.1.b:

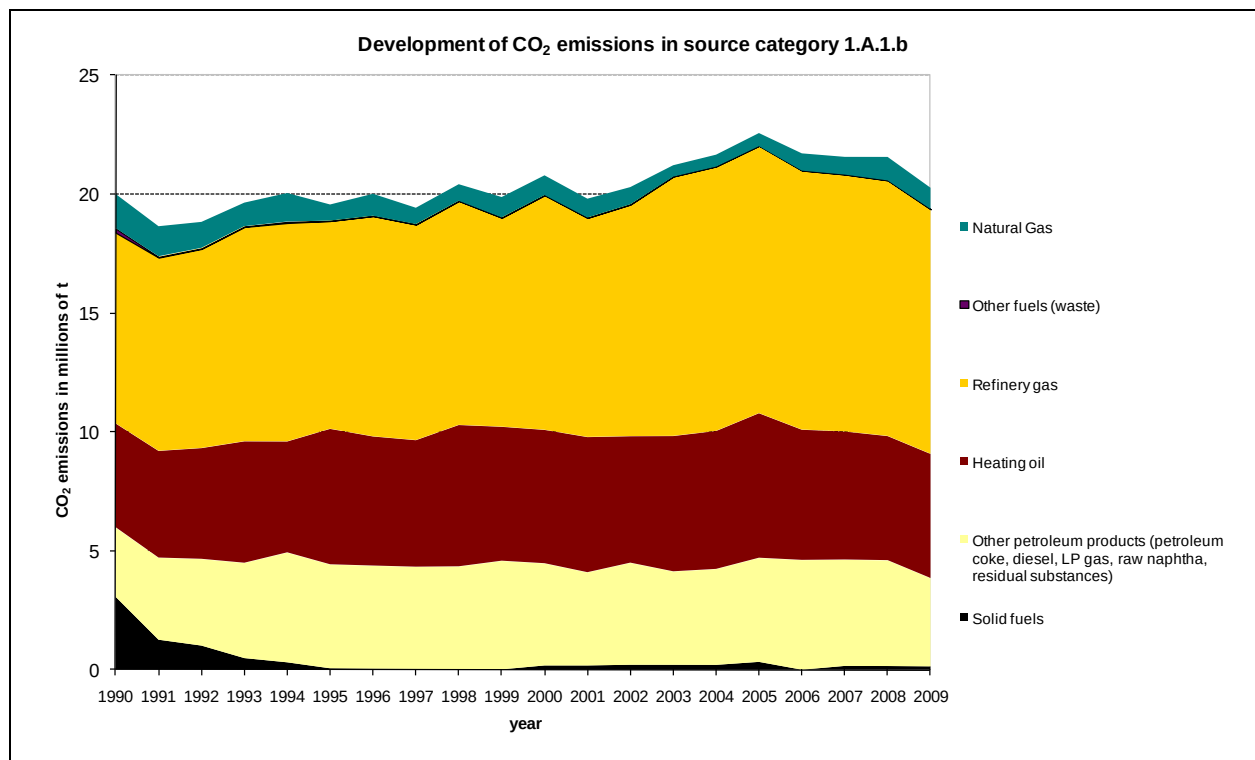


Figure 26: Development of CO₂ emissions in source category 1.A.1.b

Since 1990, emissions have shown a slightly increasing trend overall. While some relevant installations have been decommissioned since 1990 – although such decommissioning has taken place on a smaller scale than that seen in the hard-coal and lignite mining sectors – production increased nevertheless. And while installation efficiencies were improved, increased production of lighter petroleum products, and intensified ultra-hydrodesulphurisation, led to increases in specific fuel consumptions. The emissions fluctuations that have occurred over the years can be explained as the result of differences in production quantities. The maximum production of petroleum products to date, totalling 123.6 million t, occurred in 2005. The pertinent emissions were correspondingly high. Thereafter, production decreased, to a level of 110.8 million t of petroleum products in 2009, and emissions decreased as a result.

3.2.7.2 Methodological issues (1.A.1.b)

Activity data

Fuel inputs for electricity production in refinery power stations are included in Energy Balance line 12 ("Industrial thermal power stations"). Energy Balance lines 38 and 39 show energy consumption (for heat production) of refineries and used-oil-processing facilities. Fuel inputs for heat production in refinery power stations, and for bottom heating in refinery processes, are derived from these figures.

The time-series structure that results from the breakdown of energy inputs from the Energy Balance, in the BEU model, is shown in the Figure "Structural allocation, 1.A.1.b Refineries".

Activity data for refineries are determined with the help of figures of the Federal Statistical Office, and of the Federal Office of Economics and Export Control (BAFA), for fuel inputs for electricity and heat production in petroleum refining.

The BAFA statistics include figures for total fuel inputs of refineries (refineries and processing of used oil). For calculation of activity data for electricity production, energy inputs for heat production (EB line 38) and for used-oil processing (EB line 39) are subtracted from those figures. That procedure shows what amount of the energy input in Energy Balance line 12 must be allocated to refinery power stations.

The data of the *Federal Statistical Office* relative to electricity and heat production in refinery power stations cannot be adopted directly, since the data-collection methods of BAFA and the Federal Statistical Office differ. While BAFA's data show only refineries' own consumption, the "Statistik" 067 and 060 published by the *Federal Statistical Office* cover all of the fuels used by refinery power stations. Since refinery power stations also feed electricity into the public grid, the Federal Statistical Office's figures are higher than the corresponding figures of BAFA. Other relevant differences occur in the definitions used for the fuels "heating oil, heavy" and "other petroleum products". In comparison to the BAFA data, the data of the Federal Statistical Office show a larger quantity of other petroleum products overall and a smaller quantity of heavy heating oil. The Energy Balance uses BAFA's mineral-oil statistics for orientation. In the interest of maintaining consistency with the Energy Balance, the ratio between a) the fuel inputs for heat production in refinery power stations and b) the fuel inputs for electricity production in refinery power stations is calculated, on a fuel-specific basis, from the Federal Statistical Office's statistics. That factor, in conjunction with fuel inputs for electricity production in refinery power stations, can then be applied to the fuel consumption given by BAFA in order to calculate fuel inputs in refinery power stations for heat production.

The activity data for refinery-process bottom heating are obtained by subtracting fuel inputs in refinery power stations for heat production from refineries' final energy consumption (EB line 38 Refineries).

Energy inputs in facilities for used-oil processing (EB line 39) are reported under 1.A.1.c "Other transformation sector".

Emission factors (except for CO₂-emission factors)

The emission factors for refinery power stations have been taken from the research project Rentz et al. (2002). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The cited project does not provide any emission factors for the bottom-heating systems that supply process heat. To compensate for this gap, for bottom-heating systems the same values for N₂O and CH₄ were chosen that are used for refinery power stations.

3.2.7.3 Uncertainties and time-series consistency (1.A.1.b)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion systems" (Chapter 13.6 of the NIR 2007).

3.2.7.3.1 Result for N₂O

The values for the relative uncertainty are on the order of about 0.6. The pertinent comments made in Chapter 3.2.6.3.2 also apply, *mutatis mutandis*.

3.2.7.3.2 Result for CH₄

The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

3.2.7.3.3 Time-series consistency of emission factors

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.7.4 Source-specific quality assurance / control and verification (1.A.1.b)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

With regard to emission factors, the results of Chapter 3.2.6.3 apply mutatis mutandis.

3.2.7.5 Source-specific recalculations (1.A.1.b)

Changes result only for the year 2008, for which provisional figures were replaced with final statistics.

The resulting changes are as follows:

Solid fuels: + 20,252 t CO₂

Liquid fuels: - 348,575 t CO₂

Gaseous fuels: + 289,158 t CO₂

3.2.7.6 Source-specific planned improvements (1.A.1.b)

No improvements with regard to **activity data** are planned at present.

The planned new research project described in Chapter 3.2.6.6, aimed at updating **emission factors** (except for those for CO₂) will also cover power stations and bottom-heating systems in petroleum refineries.

3.2.8 Manufacture of solid fuels and other energy industries (1.A.1.c)

3.2.8.1 Source category description (1.A.1.c)

CRF 1.A.1c										
Key source by level (l) / trend (t) / Tier 2 (T2)			Gas (key source)	1990 – contribution to total emissions		2009 – contribution to total emissions		Trend		
All Fuels	I / t / T2		CO ₂	5.27 %		1.39 %		-79.8 %		
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 5	+/-50	-	-	-	+/- 50				
Distribution of uncertainties	U	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

The source category *Manufacture of solid fuels and other energy industries* is a key source, in terms of both emissions level and trend, of CO₂ emissions.

The above figures refer to power stations, and to other boiler furnaces for production of steam and hot/warm water, in source category 1.A.1.c.

Source category 1.A.1.c includes hard-coal and lignite mining, coking and briquetting plants and extraction of crude oil and natural gas. In 2009, the German hard-coal mining sector extracted 13.8 Mt of usable hard coal (17.1 Mt in 2008) (STATISTIK DER KOHLEWIRTSCHAFT 2010: for the year 2009, Übersicht (Overview) 1, and www.kohlenstatistik.de). Coke production in 2009 amounted to 6.8 Mt (STATISTIK DER KOHLEWIRTSCHAFT 2010). Production of hard-coal briquettes was discontinued in 2008.

In 2009, 169.9 Mt of crude lignite was produced in Germany (www.kohlenstatistik.de). Combined production of lignite briquettes and other lignite products amounted to about 5.8 Mt (www.kohlenstatistik.de). Steam for drying of raw lignite, for production of refined lignite products, is obtained from lignite-fired power stations with process-steam extraction (CHP plants). From these plants, steam is drawn off for drying crude lignite for production of lignite products.

In 2009, German production of petroleum totalled 2.08 Mt (MWV, 2010), while production of natural gas totalled about 14,495 Nm³ (AGEB, 2010). The fuel inputs required for installations' own operations are reported in source category 1.A.1.c.

In the CSE, source category 1.A.1.c Manufacture of solid fuels and other energy industries includes electricity and heat production in steam-turbine power stations, broken down by hard-coal mining and lignite mining (mine power stations); electricity and heat production in gas turbines, gas engines and diesel engines of all colliery and mine power stations; other heat production in industrial boilers within the transformation sector (not including refineries); and manufacture of hard-coal coke and operation of diesel engines for propulsion purposes in colliery and mine power stations. In reporting, they are broken down into the categories "large combustion systems" and "plants falling under the Technical Instructions on Air Quality Control" (TA Luft).

The following figure provides an overview of emissions trends in source category 1.A.1.c:

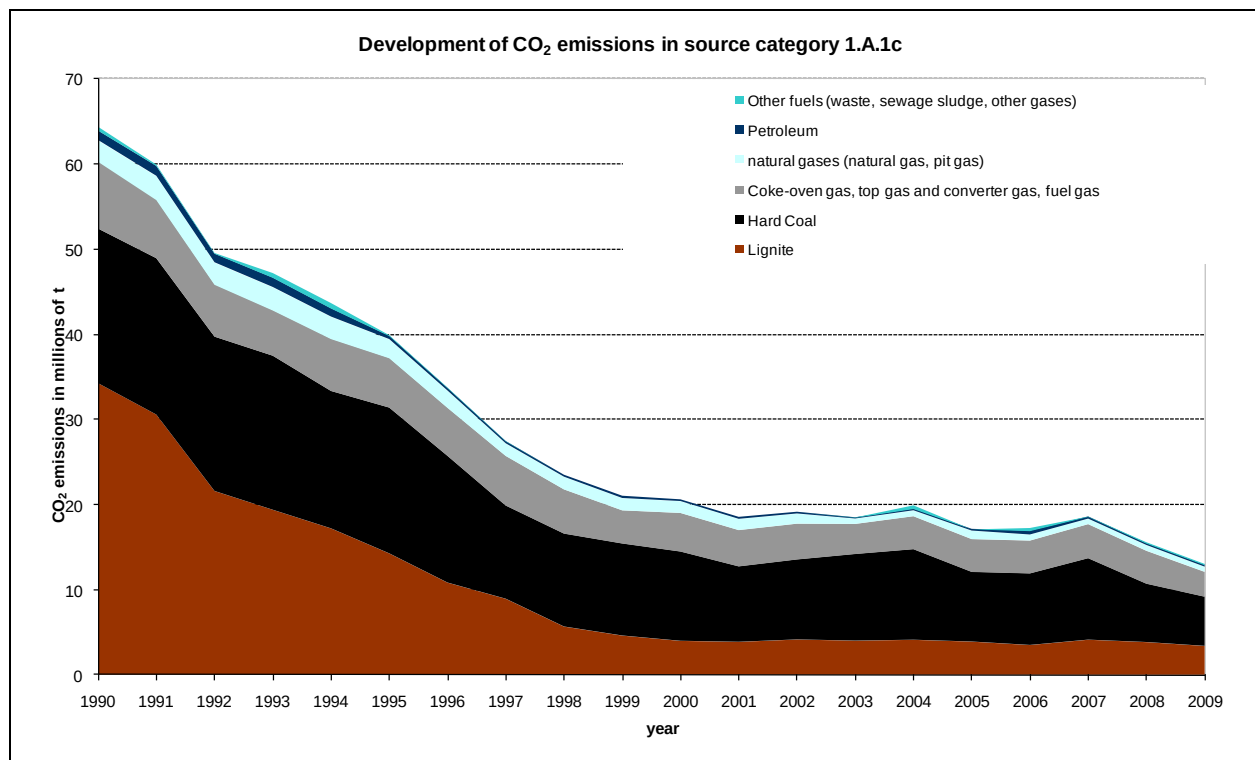


Figure 27: Development of CO₂ emissions in source category 1.A.1.c

The figure clearly shows how sharply emissions in this source category have decreased since 1990. The largest emissions decrease occurred in the area of lignite, use of which decreased strongly in the new German Länder from usage levels of the industry of the former GDR. From raw lignite, a range of refined products used to be produced for industry, households and small commercial operations. A comprehensive transition from lignite to other fuels then took place until the end of the 1990s. In a – then considerably reduced – number of industrial plants and commercial operations, use of hard coal, petroleum and natural gas intensified, while coal-burning stoves in homes were replaced with more modern heating systems fired with heating oil and natural gas. As a result, coal briquette and dust production in the new German Länder decreased from nearly 39 million t in 1990 to about 2.6 million t in 1997. Most lignite-processing plants were closed in that period, and thus emissions decreased sharply. As of 1998, energy for drying lignite products in the new German Länder was provided solely via process steam from public power stations. In the old German Länder, improvements in plants' efficiencies, along with reduced production in that area as well, until 2003, reduced emissions. Thereafter, emissions increased again slightly, as a result of production increases.

Emissions from use of hard coal in sector 1.A.1.c have been decreasing markedly since 1990. That decrease is due, firstly, to a sharp reduction in hard coal mining; while hard coal production still exceeded 70 million t in 1990, by 1997 it amounted to just less than 14 million t. Secondly, the decrease is due to the fact that some installations have shifted, for reporting purposes, from the hard coal mining category to the public electricity supply category, thereby shifting their emissions as well.

Use of industrial gases (coke-oven gas, top gas and converter gas) also decreased until the end of the 1990s. The primary reason for this is that city-gas production was phased out through 1996, in a process involving decommissioning of local gas works. Coke production also decreased markedly. Production of hard coal coke decreased from 19 million t in 1990 to

less than half of that figure in 2008. In 2009, production decreased still further, reflecting low levels of steel production. While 8 mine coking plants were still in operation in 1990, only one such plant is in operation today, along with a total of four metallurgical coking plants. Overall, plant closures and efficiency increases have decreased emissions markedly in this sector.

3.2.8.2 Methodological issues (1.A.1.c)

The calculation method has been selected on the basis of the latest key-source analysis.

Fuel inputs for electricity production in power stations of the hard-coal and lignite mining sector are listed in Energy Balance line 12, "Industrial thermal power stations". Fuel inputs for heat production in the transformation sector are listed in Energy Balance lines 33-39 and in sum line 40 ("Total energy consumption in the transformation sector").

Fuel inputs for electricity production in power stations of the hard-coal mining sector are determined with the help of figures of the Federal Statistical Office (*FEDERAL STATISTICAL OFFICE*, 2009d). The activity data for heat production in power stations of the hard-coal mining sector correspond to Energy Balance line 34 "Energy input in collieries and briquette plants of the hard-coal mining sector".

The listed fuel input for electricity production in mine power stations is based on association information (personal communication from DEBRIV, the federal German association of all lignite producing companies and their affiliated organisations). Inputs for heat production, especially for lignite drying for production of lignite products, are not shown in the Energy Balance. Those are calculated from figures for production of lignite products (STATISTIK DER KOHLENWIRTSCHAFT 2010) and from the specific fuel inputs required for drying (personal communication from DEBRIV, February 2007), listed as "non- Energy-Balance inputs" in the CSE, and reported as such.

The quantities of fuel used for production of hard-coal coke are taken directly from the Energy Balance, line 33 (coking plants).

The fuel input for heat production in the remaining transformation sector is obtained by combining the energy consumption figures in Energy Balance lines 33 to 39 (total energy consumption in the transformation sector). Those figures include mines' own consumption; facilities for petroleum and natural gas production and for processing of old oil; plants that produce coal products; plants for production and processing of fissile and fertile materials; and wastewater-treatment facilities' own consumption.

As of the 2011 report, CO₂ emissions from top-gas combustion in coking plants are reported in source category 1.A.1.c. The following table provides an overview of CO₂ emissions from top-gas use in coking plants, for the entire time series since 1990.

CO ₂ emissions from top-gas combustion in coking plants [millions of t of CO ₂]									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5.328	5.234	4.579	4.220	5.201	4.899	4.686	4.947	4.342	3.131
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3.636	3.725	3.668	3.015	3.341	3.308	3.293	3.332	3.230	2.421

Revision of the data for 1990, and for the years 1991-1994, for the new German Länder is described in Annex 19.1.1.

Emission factors (except for CO₂-emission factors)

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in source category 1.A.1.c, have been taken from RENTZ et al (2002). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3.

Within the sector, the research project differentiates between STEAG power stations, other power stations in the hard-coal mining sector, power stations in the lignite mining sector and other boiler combustion for production of steam and hot/warm water.

3.2.8.3 Uncertainties and time-series consistency (1.A.1.c)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

The procedure for determining uncertainties for the emission factors is described in Chapter 3.2.6.3.1.

3.2.8.3.1 Result for N₂O

Relatively large numbers of fluidised-bed combustion systems are used in plants within the lignite-mining sector – which plants are part of sector 1.A.1.c. Such systems are known to have relatively higher N₂O emissions than systems using other types of coal-combustion technologies. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, particularly in fluidised-bed combustion, has been specifically studied, especially in the 1990s. For this reason, enough measurement data were available to permit systematic survey of N₂O emission factors in the research project. The values for the relative uncertainty of the emission factors are on the order of about 0.6. The pertinent comments made in Chapter 3.2.6.3.2 also apply, mutatis mutandis.

3.2.8.3.2 Result for CH₄

The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

3.2.8.3.3 Time-series consistency of emission factors

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.8.4 Source-specific quality assurance / control and verification (1.A.1.c)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of Chapter 3.2.6.4 apply mutatis mutandis.

3.2.8.5 Source-specific recalculations (1.A.1.c)

CO₂ emissions increase markedly throughout the entire time series, since emissions from top-gas use in coking plants are no longer reported in source category 2.C.1. The pertinent emissions figures are listed in tabular form in Chapter 3.2.8.2 Methodological issues (1.A.1.c).

Fuel inputs were recalculated for 2008, for which final statistics became available to replace provisional data. The resulting changes are as follows:

Solid fuels:	- 1,121,696	t CO ₂
Liquid fuels:	- 42,680	t CO ₂
Gaseous fuels:	+ 88,152	t CO ₂
Other fuels:	+ 108,806	t CO ₂

3.2.8.6 Source-specific planned improvements (1.A.1.c)

The new research project described in Chapter 3.2.6.6, for updating of emission factors (except for those for CO₂), also covers power stations and other combustion systems in the mining sector.

3.2.9 Manufacturing industries and construction (1.A.2)

This source category consists of several sub- source categories defined in close harmony with the IPCC categorisations (CRF). It is described in detail via the relevant sub-chapters.

The calculation algorithms for BEU structural elements in source category 1.A.2 were revised, within the research project "Substantiation of the data quality of activity data" (FKZ 204 41 132), and they are now governed by a consistent system. For the most part, they are based on reliable data of the Federal Statistical Office.

Sectoral differentiation of activity data was carried out solely for process combustion.

As of 2008, classification of economic sectors (Wirtschaftszweige = WZ), in energy statistics, is being changed from the "WZ 2003" standard to the "WZ 2008" standard. As a result, activity data relative to process combustion are now being taken from individual statistics in keeping with the relevant key for the change (STATISTISCHES BUNDESAMT 2008d: "Umsteigeschlüssel WZ 2003 auf WZ 2008" (key for the change from WZ 2003 to WZ 2008))

With respect to power and heat production, industrial power stations and boiler systems are aggregated by technologies (gas engines, gas turbines, gas and steam plants and steam turbines), as well as by permit-law provisions (TA-Luft and 13. BImSchV).

The various individual calculation algorithms were substantiated in detail in the aforementioned research project.

In the current report year, the calculation algorithm for the CRF category "Manufacturing industries and construction – iron and steel" (1.A.2.a) was revised, in keeping with the availability of more highly disaggregated data sources. As a result of the calculation methods involved, this has also led to changes in the area of boilers (1.A.2.f Other).

Following emissions calculation at the structural-element level, sum values for the sub-source categories in 1.A.2 are formed, via maximally IPCC-conformal aggregation of results. Since the NIR 2006, most process combustion has been reported on a sector-specific basis. The available data does not permit fully IPCC-conformal disaggregation. For example, heat and power production of industrial power stations and thermal power stations cannot be oriented to specific sectors; for this reason, it is reported in combined form, under 1.A.2.f Other.

Differentiation of energy-related process combustion for heat and power production in industrial power stations and in boiler systems was carried out via Statistik 067 (Statistics 067; electricity-production systems of the manufacturing sector, and of the mining and quarrying sectors (Stromerzeugungsanlagen des Verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden); *FEDERAL STATISTICAL OFFICE*, 2009c).

A change in Statistics 067 (op. cit.) of the Federal Statistical Office has led to a jump in the activity data for heat and electricity production. Until 2001, only the fuel inputs for electricity production in electricity production systems were listed. As of 2002, fuel inputs for heat and electricity production are listed. No data are available for inputs for heat production for years prior to 2002.

The ratio between the fossil and biogenic fractions in industrial waste is obtained from the Energy Balance and the relevant industry association figures for substitute fuels.

All of the listed amounts of standard fuels used in all sub- source categories have been taken from the Energy Balance of the Federal Republic of Germany and disaggregated in the *Balance of Emission Causes* (BEU). In addition to the figures provided from the Energy Balance, in various sub- source categories substitute fuels have now been listed. The relevant amounts were determined in a research project (UBA 2005b, FKZ 204 42 203/02) and are now updated annually with the help of association data (see below). As these figures show, use of substitute fuels has been increasing. This has led to reductions in use of conventional fuels, via de facto fuel substitutions.

In the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; (UBA 2005b, FKZ 204 42 203/02)), the required improvements relative to the topic of "waste fuels" in the energy sector were found to be tied to substitute fuels in four industrial sectors, and the pertinent data were obtained from the relevant industrial associations. As a result, considerably improved, sector-specific data are now available relative to use of substitute fuels in process combustion, and in industrial power stations, in the industrial sectors pig-iron production, pulp and paper production and lime and cement production.

Special aspects of the various sub- source categories are described in the relevant sub-chapters. Special note should be taken of the collective group 1.A.2.f Other.

The uncertainties for the new structural elements created in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; (FKZ 204 41 132) were determined in keeping with the method described in the research project 204 42 203/02. That determination is described in the final report for the research project (FKZ 204 41 132) and in Annex 13.6 of the NIR 2007.

Carbon dioxide emissions predominate in CRF category 1.A.2. Other greenhouse gases account for only very small shares of total emissions.

A sharp reduction in greenhouse-gas emissions occurred in the period 1990 through 1994. It was caused by decommissioning of inefficient manufacturing plants in the new German Länder following the 1990 political transition in Germany.

The emissions fluctuations that occurred in subsequent years reflect production trends in Germany's manufacturing sector, which were tied to overall economic trends.

3.2.9.1 Manufacturing industries and construction – iron and steel (1.A.2.a)

CRF 1.A.2.a					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	I / -	CO ₂	1.28 %	1.23 %	-25.8 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties	N									
EF-determination method	CS									

The source category *Manufacturing industries and construction – iron and steel* is a key category, in terms of emissions level, for CO₂ emissions.

The iron and steel industry (sub- source category 1.A.2.a) is the second important CO₂-emissions source, along with the cement industry, in the area of process combustion.

3.2.9.1.1 Source category description (1.A.2.a)

The source category comprises the production areas of pig iron (blast furnaces), sinter, rolled steel, iron and steel casting, Siemens-Martin steel and electric steel.

Production of Siemens-Martin steel generated emissions only in the new German Länder, and only until shortly after 1990. Thereafter, production was completely discontinued. In the old German Länder, production of Siemens-Martin steel was discontinued before 1990.

In production of pig iron, large amounts of the fuels used in blast furnaces are needed for the reduction processes that take place in the furnaces, while most of the fuel used in other production areas of the iron and steel industry is used for heat production.

The following figure provides an overview of CO₂ emissions in the various sub- source categories in 1.A.2.a.

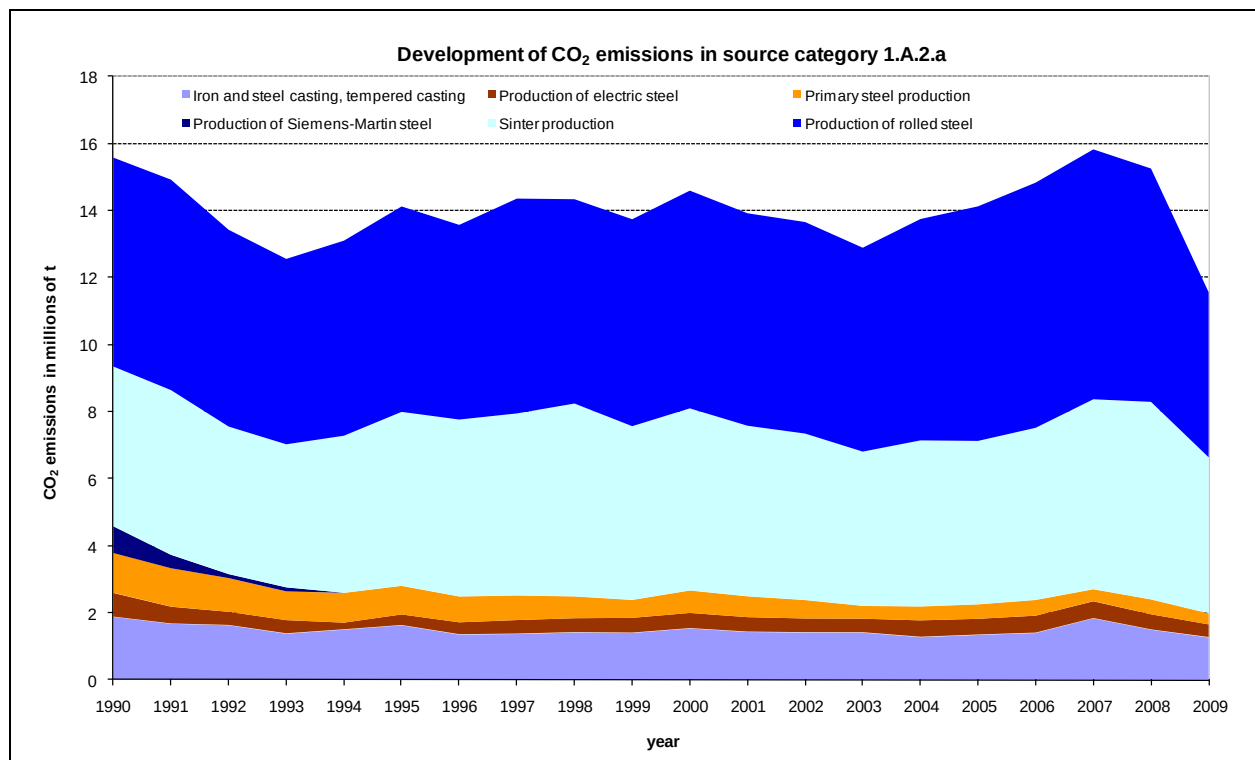


Figure 28: Development of CO₂ emissions in source category 1.A.2.a

As the overview reveals, major fluctuations have occurred over the years. In most cases, those swings were tied to fluctuations in production. In the period 1990 through 1994, emissions reductions occurred primarily as a result of restructuring of the iron and steel sector in the new German Länder following the political transition of 1990.

The drop in CO₂ emissions is particularly pronounced in the crisis year 2009, in which the steel industry registered a sharp production decrease.

The largest emissions share comes from the areas of rolled-steel and sinter production. In the blast furnace category, only the natural-gas and coking-gas inputs required for furnace operation are reported in source category 1.A.2.a. Process-related emissions are listed in source category 2.C.1.

3.2.9.1.2 Methodological issues (1.A.2.a)

This sub- source category comprises process combustion in the various production areas of the iron and steel industry. The relevant fuel-use amounts, including those for secondary fuels, are contained in the Balance of Emission Causes (BEU).

In work to obtain activity data for conventional fuels in this source category, it proved possible to develop a new data source: the so-called "BGS" group (fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations), which is a data category for statistics on "Manufacturing industries and construction: iron and steel". This improved relevant disaggregation.

In the current reliability, the "iron and steel industry" area has been thoroughly revised on the basis of data from the BGS group.

In addition to providing activity data for sintering plants, blast furnaces, basic oxygen furnaces (converters) and rolling mills, BGS-group data support additional disaggregation of the electric steel sector.

This has improved processing of activity data relative to inputs of solid and gaseous fuels.

With the BGS-group data, data-based differentiation of the solid-fuel categories "hard coal and hard coal briquettes"; "coke" and "coke breeze with particle size less than 10 mm" has become possible for the first time. Fuel inputs for coke and coke breeze are summed, and listed under "coke".

The "liquid fuels" listed for the BGS group are classified under "heating oil, heavy".

The BGS-group data list fuel inputs in natural units. For the present purpose, those units are converted into energy units, using the relevant net calorific values listed by the Working Group on Energy Balances (AGEB).

For gases, the BGS-group data use a norm of 35.16912 MJ/m³. That figure has been adopted in the methods for calculating activity data for blast-furnace gas, coke-oven gas, natural gas and converter gas.

The method for calculating emissions from secondary fuels has been retained, in keeping with the results of the research project "Einsatz von Sekundärbrennstoffen" ("Inputs of secondary fuels"; UBA 2005b, FKZ 204 42 203/02).

In the area of emissions from the iron and steel industry, a distinction is made, for the entire time series as of 1990, between process-related emissions and energy-related emissions. The method for calculation of process-related emissions is described in Chapter 4.4.1.2 of source category 2.C.1.

3.2.9.1.3 Uncertainties and time-series consistency (1.A.2.a)

Uncertainties were determined for all fuels in 2004 (except for substitute fuels), and for substitute reducing agents, with regard to the entire time series. The relevant method is described in a research report (UBA 2005b, FKZ 204 42 203/02). The uncertainties have been updated for the activity data in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

The uncertainties were not considered anew, since the data used for calculation have been taken from Fachserie 4 Reihe 8.1 of the Federal Statistical Office, which source aggregates the data on the basis of the BGS-group classification ("BGS-Bogen" = the "BGS form").

Seen from a conservative perspective, further improvement of classification of data by individual production stages, on the same data basis (the BGS-group form), does not change the relevant uncertainties in any way. The BGS-group data are available for the period until 1990; consequently, the time series is consistent. Legislation is currently being prepared that would ensure the continued availability of the data in the current form.

3.2.9.1.4 Source-specific quality assurance / control and verification (1.A.2.a)

Quality control (pursuant to Tier 1) and quality assurance for the activity data, in conformance with the requirements of the QSE manual and its associated applicable documents, have

been carried out. Quality control (pursuant to Tier 1), and quality assurance for the EF and ED, have been carried out by the Single National Entity.

Source category 1.A.2.a, in conjunction with source category 2.C.1, presents extremely complex issues, since there are discrepancies between pertinent methods used in connection with the Energy Balance, with emissions reporting, with emissions trading and with relevant association statistics. In the interest of data quality assurance, regular experts' discussions have to be carried out for the purpose of comparing and evaluating data.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.1.5 Source-specific recalculations (1.A.2.a)

New calculations for the years as of 1990 have been carried out, because the calculations as of 1990 have been extensively revised, methodologically, on a basis of improved data disaggregation. The following table shows the relevant changes, for the entire time series as of 1990.

Table 30: Recalculations for CO₂ in CRF 1.A.2.a

Year	Solid fuels [t CO ₂]	Liquid fuels [t CO ₂]	Gases [t CO ₂]	Other [t CO ₂]	Total [t CO ₂]
1990	1,717,916	339,989	946,059	0	3,003,964
1991	2,769,207	351,507	1,012,436	0	4,133,150
1992	2,437,222	289,965	713,853	0	3,441,040
1993	3,789,461	229,814	677,962	0	4,697,237
1994	2,486,425	89,739	652,394	0	3,228,558
1995	2,827,768	118,181	495,779	0	3,441,728
1996	1,272,236	133,428	471,335	0	1,876,999
1997	3,049,676	120,015	433,193	0	3,602,884
1998	1,186,925	81,729	406,664	0	1,675,319
1999	1,066,189	60,300	341,806	0	1,468,295
2000	1,765,987	84,700	447,743	0	2,298,430
2001	1,175,924	103,238	541,400	0	1,820,562
2002	1,683,513	117,024	398,664	0	2,199,201
2003	694,013	109,263	155,655	0	958,932
2004	3,745,905	68,999	113,467	0	3,928,371
2005	4,870,572	50,111	123,850	0	5,044,532
2006	4,332,787	60,659	166,136	0	4,559,582
2007	6,898,827	121,507	-267,789	0	6,752,546
2008	3,746,035	214,306	-81,174	0	3,879,167

3.2.9.1.6 Source-specific planned improvements (1.A.2.a)

No improvements are planned at present.

3.2.9.2 Manufacturing industries and construction – non-ferrous metals (1.A.2.b)

CRF 1.A.2.b					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
		- / -			

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS									

The source category "Non-ferrous metals" is not a key source.

3.2.9.2.1 Source category description (1.A.2.b)

This source category aggregates process combustion of various areas of non-ferrous-metal production. The available data does not support more detailed description.

3.2.9.2.2 Methodological issues (1.A.2.b)

he pertinent fuel inputs are contained in the Balance of Emission Causes (BEU). The source for fuel inputs consists of statistics for the manufacturing sector (Statistik 060 – Energieverwendung des produzierenden Gewerbes (energy use in the manufacturing sector; *FEDERAL STATISTICAL OFFICE*, 2009b) (Melde-Nr. (reporting number) 27.43 (WZ 2003 old; WZ = classification system for economic data) → 24.43 (WZ 2008 new); Erzeugung und erste Bearbeitung von Blei, Zink und Zinn (production and initial processing of lead, zinc and tin) 27.44 (WZ 2003 old) → 24.44 (WZ 2008 new); Erzeugung und erste Bearbeitung von Kupfer (production and initial processing of copper)) and, for differentiations relative to heat and electricity production, Statistik 067 (*FEDERAL STATISTICAL OFFICE*, 2009c).

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of such revision, production and initial processing of precious metals, aluminium and other non-ferrous metals are now taken into account in determination of activity data.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The 1990 activity data for the new German Länder were revised and substantiated, with the help of new data, in the project "Base year and updating" ("Basisjahr und Aktualisierung" (UBA 2005c: FKZ 205 41 115); see Annex Chapter 19.1.1).

3.2.9.2.3 Uncertainties and time-series consistency (1.A.2.b)

For 2004, the uncertainties for all activity data were determined for the first time. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.2.4 Source-specific quality assurance / control and verification (1.A.2.b)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for the EF and ED carried out by source-category experts. Quality

assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.2.5 Source-specific recalculations (1.A.2.b)

For this source category, this year recalculations were carried out for the year 2008, because the pertinent final Energy Balance (updated) became available; the last report made use of the provisional Energy Balance. The recalculations have led to the following changes in CO₂ emissions for 2008:

Solid fuels:	+ 13,184	t CO ₂
Liquid fuels:	+ 12,190	t CO ₂
Gaseous fuels:	+ 11,025	t CO ₂

Recalculations, with minor consequences, were also carried out for 1990, 1994 and 1996, to take account of pertinent error correction.

3.2.9.2.6 Source-specific planned improvements (1.A.2.b)

No improvements are planned at present.

3.2.9.3 Manufacturing industries and construction – Chemicals (1.A.2.c)

CRF 1.A.2.c					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	IE	IE	IE	IE	IE

The chemical industry's process combustion and own power production are not listed separately; instead, they are summarised in 1.A.2.f Other.

Fuel inputs in calcium-carbide production are process-related and are reported under CRF 2.B.4 (cf. Chapter 4.3.4).

This approach has been confirmed by the research project "Base year and updating" (UBA 2005c, FKZ 205 41 115), for 1990 in the new German Länder (the most important production location): the relevant coke was used as a production material and not as a fuel for energy. Calcium-carbide production is thus not a source of energy-related CO₂ emissions.

The emissions for the entire sub- source category 1.A.2.c are thus included elsewhere (IE). 1.A.2.c has not been listed separately in the key-source analysis.

3.2.9.4 Manufacturing industries and construction – Pulp, paper and print (1.A.2.d)

CRF 1.A.2.d

Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
- / -				

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	NE	NO	NO	NO	NE	NE	NE	NE	NE
EF uncertainties in %	-50 / +90									
Distribution of uncertainties	N									
EF-determination method	CS									

The source category *Pulp, paper and print* is not a key source.

3.2.9.4.1 Source category description (1.A.2.d)

The energy consumption for production of pulp, paper and printed products – otherwise referred to as the "pulp and paper industry" for short – can be described only for substitute fuels, of which this industry uses large amounts.

Emissions from use of regular fuels in process combustion, and emissions generated by plants in own-power production, have not been listed separately. They are summarised under 1.A.2.f Other.

3.2.9.4.2 Methodological issues (1.A.2.d)

Only some of the substitute fuels used by the paper industry are listed in the Energy Balance. The fuels in question consist of waste from the relevant sectors' own production areas. The data on the types and amounts of substances used were provided by the German Pulp and Paper Association (VDP). The great majority of the substitute fuels used in the sector consist of wood and pulp fibres – and, thus, of biomass. The biogenic and fossil fractions of pertinent fuels were derived in the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen") (UBA 2005b, FKZ 204 42 203/02). In addition, CO₂ emission factors were derived on the basis of data on carbon content, water content and net calorific values.

Table 31: Inputs of secondary fuels in the pulp and paper industry: CO₂ emission factors and their biogenic components

Secondary fuel (designation in the CSE)	CO ₂ emission factor [kg/ TJ]	Biogenic mass fraction [%]
Spent liquors from pulp production	74,046	100
Bark	80,611	100
Fibre/de-inking residues	54,871	100
Paper-industry residues	86,222	95

Remark: The listed biogenic fractions include no data on inorganic carbon fractions (TIC, such as carbonates); the emission factor has been derived from the organic fraction (TOC). Since in EU emissions trading both TIC and TOC are to be taken into account, these figures have little suitability for comparisons and for use in calculations for individual plants.

3.2.9.4.3 Uncertainties and time-series consistency (1.A.2.d)

In the framework of a research project, the uncertainties of the CO₂ emission factors derived for substitute fuels were determined using the Monte Carlo method (UBA 2005b, FKZ 204 42 203/02). In the procedure, figures for C content, water content and net calorific

value were taken into account. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO₂ emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

3.2.9.4.4 Source-specific quality assurance / control and verification (1.A.2.d)

Quality control (pursuant to Tier 1), and quality assurance for the EF, have been carried out by the Single National Entity.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD.

The paper industry has long kept records of inputs of secondary fuels (VDP, various years). In spite of small structural breaks in the time series in such records, the records clearly show the paper industry's increasing use of substitute fuels in place of regular fuels.

3.2.9.4.5 Source-specific recalculations (1.A.2.d)

No recalculations are required.

3.2.9.4.6 Source-specific planned improvements (1.A.2.d)

No improvements are planned at present.

3.2.9.5 Manufacturing industries and construction – Sugar production (1.A.2.e)

CRF 1.A.2.e					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	- / t	CO ₂	0.16 %	0.02 %	-91.8 %

Gas	CO₂	CH₄	HFC	PFC	SF₆	N₂O	NO_x	CO	NMVOC	SO₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS									

The Sugar production source category is a key category for CO₂ emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-91.8 %), and thus an extremely low emissions level has been attained (in 2009, emissions amounted to 4.8 % of the contribution of the smallest key source identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key sources.

3.2.9.5.1 Source category description (1.A.2.e)

This source category includes only the sugar industry's process combustion. Plants generating their own power are not listed separately; they are reported under 1.A.2.f Other.

3.2.9.5.2 Methodological issues (1.A.2.e)

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of this revision, it was determined that the statistics publications Statistik 060 (*FEDERAL STATISTICAL OFFICE*, 2009b) and Statistik 067 (*FEDERAL STATISTICAL OFFICE*, 2009c) list all of the fuels required for calculation of the pertinent activity data and should be used as data sources.

The relevant calculation algorithms, and special analyses relative to fuel inputs, are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.5.3 Uncertainties and time-series consistency (1.A.2.e)

For 2004, the uncertainties for all activity data were determined for the first time. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.5.4 Source-specific quality assurance / control and verification (1.A.2.e)

Quality control (pursuant to Tier 1) and quality assurance have been carried out, by the Single National Entity, for the EF.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.5.5 Source-specific recalculations (1.A.2.e)

For this source category, this year recalculations were carried out for the year 2008, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

The recalculations have led to the following changes in CO₂ emissions:

Solid fuels: + 23,036 t CO₂

Liquid fuels: - 12,258 t CO₂

3.2.9.5.6 Source-specific planned improvements (1.A.2.e)

No improvements are planned at present.

3.2.9.6 Manufacturing industries and construction – Other (1.A.2.f, Sum)

CRF 1.A.2.f					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	l / t / T2	CO ₂	12.81 %	9.44 %	-43.4 %

The source category *Manufacturing industries and construction – Other*, the sum of all other sub- source categories, is a key source, in terms of emissions level and trend, of CO₂

emissions. Key-source analysis was carried out only for the sum of sub- source categories in 1.A.2.f.

The NIR inventory structure includes the sub- source categories 1.A.2.f Cement (structural element "Production of cement clinkers (process combustion)"), 1.A.2.f Ceramics (structural element "Production of ceramics products (process combustion)"), 1.A.2.f Glass (structural element "Production of glass (process combustion)"), 1.A.2.f Lime (structural element "Production of lime (process combustion)") and 1.A.2.f Other ("other manufacturing" in the CSE, with various structural elements).

Binding key-source analysis has been carried out. In addition, the predominant (in terms of emissions) sub- source categories have been identified. 1.A.2.f Cement and 1.A.2.f Other are worthy of special note: 1.A.2.f Cement as a significant source of process combustion, and 1.A.2.f Other as a collective group that includes emissions from heat and power production of industrial power stations and industrial boiler systems, as well as (inter alia) energy-related emissions from the chemical industry.

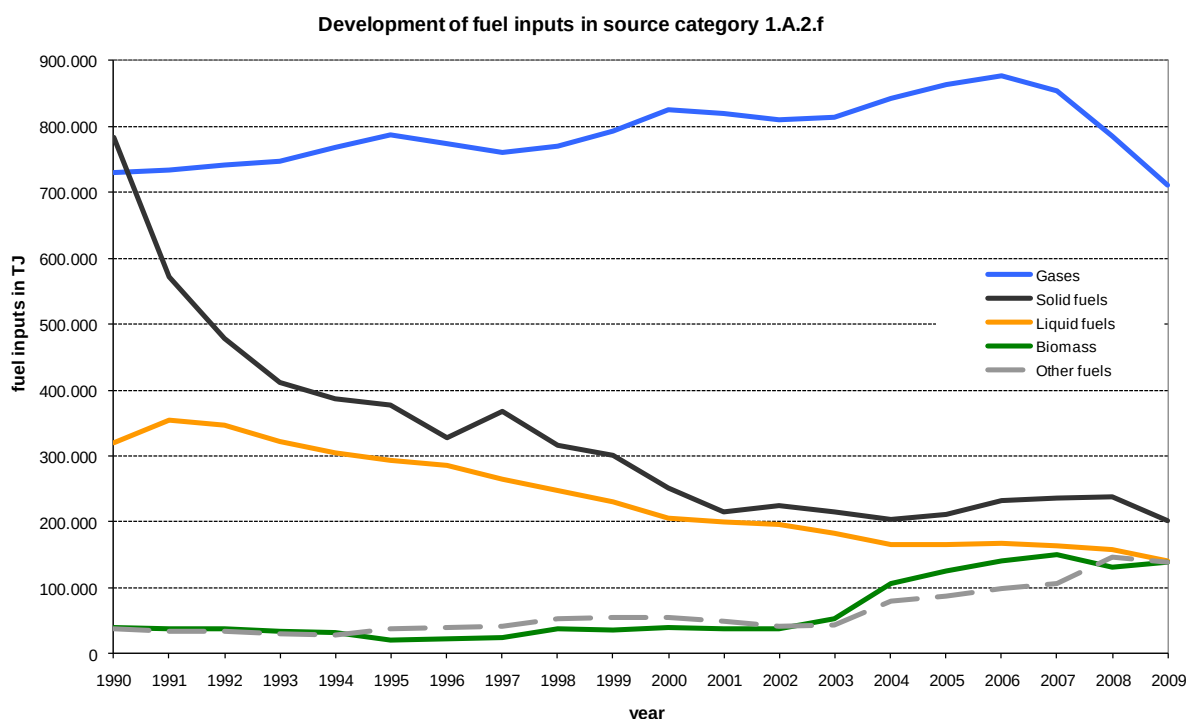


Figure 29: Development of fuel inputs in source category 1.A.2.f [y axis: fuel inputs in TJ; x axis: year; Legend: Gases; Solid fuels; Liquid fuels; Biomass; Other fuels]

This source category exhibits a marked change in fuel inputs.

A noticeable decrease in use of solid fuels has occurred, primarily via reduced use of lignite and intensified use of gas, biomass and substitute fuels.

Increased activity data for "other fuels" are the result of intensified use of substitute fuels (waste).

A statistical discontinuity is seen in the area of biomass. The available statistics fail to take account of, or to take account of completely, use of biomass for energy generation. Biomass's share of energy generation has been increasing.

3.2.9.7 Manufacturing industries and construction - Cement production (1.A.2.f, Cement)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	CS	NE	NO	NO	NO	NE	NE	NE	NE	NE
EF uncertainties in %	-30 / +30									
Distribution of uncertainties	N									
EF-determination method	CS									

Outside of the framework of binding key-source analysis, this sub- source category must be considered particularly important.

3.2.9.7.1 Source category description (1.A.2.f, Cement)

In this source category, only process combustion from burning of clinkers can be listed. The final step in cement production, i.e. grinding and mixing, is not included. As a power-intensive process, it is included in power production (1.A.1). Some plants within this category also generate power for their own use; this generation is not listed separately, but is included under 1.A.2.f Other.

In addition to substitutions of raw materials (smelter slag instead of cement clinkers, a subject not treated here in its own right), cement production involves considerable fuel substitutions in burning of clinkers. In the process, both conventional fuels, such as lignite, hard coal, oil and gas, and "secondary fuels" (waste from other economic sectors) are used. This reduces consumption of regular fuels.

3.2.9.7.2 Methodological issues (1.A.2.f, Cement)

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

The pertinent inputs of conventional fuels are contained in the Balance of Emission Sources (BEU). The source for fuel inputs for energy-related process combustion is Statistik des produzierenden Gewerbes (manufacturing-sector statistics; Melde-Nr. (reporting number) 26.51 (WZ 2003 old; WZ = classification system for economic data) → 23.51 (WZ 2008 new), Cement production). The source for pertinent differentiation from heat and electricity production is Statistik 067 (FEDERAL STATISTICAL OFFICE, 2009c).

As of 2002, the data for Statistik 067 (op. cit.) are found only among three-digit reporting numbers. This means that only data for reporting number 26.5 (WZ 2003 old) → 23.5 (WZ 2008 new) (production of cement, lime and burnt plaster) can be used as a basis.

To permit relevant separation, the individual data available for the period through 2001 for production of cement (reporting number 26.51 (WZ 2003 old) → 23.51 (WZ 2008 new)), production of lime (reporting number 26.52 (WZ 2003 old) → 23.52 (WZ 2008 new) and production of plaster (reporting number 26.53 (WZ 2003 old) → 23.53 (WZ 2008 new)) were analysed. The various types of production involved (cement, lime, plaster) were differentiated via allocation of individual fuels.

In the process, it was seen that relevant fuel inputs in electricity-generating plants were listed only for production of cement and plaster. In addition, in all years only light heating oil was listed for the cement industry, while for the plaster industry coal dust and dry coal, and natural gas and heavy heating oil, were also listed. For this reason, fuel inputs for light

heating oil (Meldenummer (reporting number) 26.5 (WZ 2003 old) → 26.5 (WZ 2008 new)) have been allocated to the cement industry, in the relevant proportions.

It is assumed that the fuel "Other petroleum products", which was reported for the first time in Statistik 067 (*FEDERAL STATISTICAL OFFICE*, 2009c) as of 2003, must also be allocated to the plaster industry, since technologies used to date in the cement industry (for use of light heating oil) are not suited for use of other petroleum products.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The fuel inputs for the new German Länder in 1990 were calculated on the basis of specific fuel consumption in 1989 and production in 1990.

The cement industry uses significant amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. Relevant production figures and fuel-use amounts have been taken from statistics of the VDZ cement-industry association. The procedure used to compile activity data oriented to the old and new German Länder as of 1990, and to all of Germany as of 1995, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 204 42 203/02). Data on the relevant types, amounts and energy contributions of the substitute fuels used were provided by the VDZ.

In a first step, fuel inputs were allocated to the groups "Biomass" or "Other fuels (waste)", in keeping with IPCC procedures. In the research project "Inputs of secondary fuels", the biogenic fractions of relevant fuels were derived and then entered into the calculations, with the help of split factors. In the same project, CO₂ emission factors were derived for substitute fuels, on the basis of data on carbon content, water content and net calorific value (UBA 2005b, FKZ 204 42 203/02).

Table 32: Inputs of secondary fuels in the cement industry: emission factors and their biogenic components

Secondary fuel (designation in the CSE)	CO ₂ emission factor [kg/ TJ]	Biogenic mass fraction [%]
Used tyres*	88,425	27
Used oil	78,689	0
Commercial waste - paper	64,881	91
Commercial waste - plastic	83,075	0
Commercial waste - packaging	56,854	40
Textile waste	63,294	70
Commercial waste - other	68,129	52.33
Animal meals and fats	74,867	100
Processed municipal waste	59,846	55
Waste wood (wood scraps)	95,056	100
Solvents (waste)	71,133	0
Carpet waste	80,425	36.50
Bleaching clay	82,260	0
Sewage sludge	95,110	100
Oil sludge	84,024	0

The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

Liquid fuels: - 39,968 t CO₂
 Gaseous fuels: + 8,957 t CO₂

3.2.9.7.6 Source-specific planned improvements (1.A.2.f, Cement)

No improvements are planned at present.

3.2.9.8 Manufacturing industries and construction - Ceramics (1.A.2.f, Ceramics)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS					CS				

3.2.9.8.1 Source category description (1.A.2.f, Ceramics)

Source category Ceramics, 1.A.2.f, includes process combustion in the brick industry, including other construction ceramics. Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

3.2.9.8.2 Methodological issues (1.A.2.f, Ceramics)

The fuel inputs for process combustion are calculated in the Balance of Emission Sources (BEU). The fuel-input data have been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes; Melde-Nr. (reporting no.) 26.40 (WZ 2003 old) → 23.32 (WZ 2008 new), Ziegelei (brickworks), production of other construction ceramics), and, for differentiation from heat and electricity production, Statistik 067 (FEDERAL STATISTICAL OFFICE, 2009c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.8.3 Uncertainties and time-series consistency (1.A.2.f, Ceramics)

Uncertainties for all fuels were determined, for the first time, for 2004 (research project "Substantiation of the data quality of activity data, FKZ 204 41 132)". The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.8.4 Source-specific quality assurance / control and verification (1.A.2.f, Ceramics)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.8.5 Source-specific recalculations (1.A.2.f, Ceramics)

For this source category, this year recalculations were carried out for the year 2008, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.2.9.8.6 Source-specific planned improvements (1.A.2.f, Ceramics)

No improvements are planned at present.

3.2.9.9 Manufacturing industries and construction - Glass (1.A.2.f, Glass production)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS					CS				

3.2.9.9.1 Source category description (1.A.2.f, Glass production)

This sub- source category includes process combustion for the areas of flat-glass production; concave-glass production; production of glass fibre; finishing and processing of flat glass; and production and finishing of other glass and technical glass products.

Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

3.2.9.9.2 Methodological issues (1.A.2.f, Glass production)

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

The source for fuel inputs for energy-related process combustion is Statistik des produzierenden Gewerbes (manufacturing-sector statistics; Melde-Nr. (reporting number) 26.1 (WZ 2003 old; WZ = classification system for economic data) → 23.1 (WZ 2008 new), Production of glass and glassware). The source for pertinent differentiation from heat and electricity production is Statistik 067 (*FEDERAL STATISTICAL OFFICE*, 2009c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.9.3 Uncertainties and time-series consistency (1.A.2.f, Glass production)

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; *FEDERAL STATISTICAL OFFICE*, 2002c), only one set of statistics has been used for Germany as a whole. This has considerably improved time-series consistency in comparison to that for the period 1990 to 1994.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and recorded in the relevant final report.

Uncertainties were determined for all activity data, for the first time, for the year 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.9.4 Source-specific quality assurance / control and verification (1.A.2.f, Glass production)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.9.5 Source-specific recalculations (1.A.2.f, Glass production)

For this source category, this year recalculations were carried out for the year 2008, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance. The resulting emissions changes are as follows:

Liquid fuels: - 46,675 t CO₂

Gaseous fuels: + 161,906 t CO₂

3.2.9.9.6 Source-specific planned improvements (1.A.2.f, Glass production)

No improvements are planned at present.

3.2.9.10 Manufacturing industries and construction - Lime (1.A.2.f, Lime production)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS									

3.2.9.10.1 Source category description (1.A.2.f, Lime production)

With regard to conventional fuels, the process-combustion figures refer to production of lime.

The reported figures for inputs of substitute fuels refer to all process combustion in German lime works.

3.2.9.10.2 Methodological issues (1.A.2.f, Lime production)

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

The relevant inputs of regular fuels are contained in the Balance of Emission Sources (BEU). The fuel-input data has been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes; Melde-Nr. (reporting no.) 26.52/lime (WZ 2003 old) → 23.52 (WZ 2008 new)).

Pursuant to Statistik 067 (*FEDERAL STATISTICAL OFFICE*, 2009c), in the years 1995 – 2001 the lime industry used no fuels for electricity production. It is assumed that this industry will continue to produce no electricity. For calculations, therefore, only Statistik 060 (*FEDERAL STATISTICAL OFFICE*, 2009b) is used.

Additional review is expected to show whether shifting seen in relevant coal use has resulted from allocation to the sugar industry.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The fuel inputs for the new German Länder in 1990 were calculated on the basis of specific fuel consumption in 1989 and production in 1990.

Since 2003, the lime industry has used minor amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. The fuel-input data was provided by the Bundesverband der Deutschen Kalkindustrie national lime-industry association. The procedure used to compile activity data oriented to the territory of Germany, for the period as of 2003, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 204 42 203/02). The data on the types and amounts of substitute fuels used were also provided by the Bundesverband der Deutschen Kalkindustrie national lime-industry association. In the research project "Inputs of secondary fuels", the biogenic fractions of relevant fuels were derived and then entered into the calculations, with the help of split factors. In the same project, CO₂ emission factors were derived for substitute fuels, on the basis of data on carbon content, water content and net calorific value (op. cit.).

Table 33: Inputs of substitute fuels in the lime industry: emission factors and their biogenic components

Secondary fuel (designation in the CSE)	CO ₂ emission factor [kg/ TJ]	Biogenic mass fraction [%]
Used oil	78,689	0
Animal meals and fats	74,867	100
Commercial waste - other	68,129	52.33

The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

3.2.9.10.3 *Uncertainties and time-series consistency (1.A.2.f, Lime production)*

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; *FEDERAL STATISTICAL OFFICE*, 2002c), only one set of conventional-fuel statistics has been used for Germany as a whole. This has considerably improved time-series consistency in comparison to that for the period 1990 to 1994.

Uncertainties were determined for all regular fuels, for the first time, for the year 2004. The relevant method is described in Annex 13.6 of the NIR 2007.

The uncertainties have been updated for the activity data in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132) and included in the relevant final report.

In the framework of the research project "Inputs of secondary fuels" (UBA 2005b, FKZ 204 42 203/02), the uncertainties of the CO₂ emission factors derived for substitute fuels were determined using the Monte Carlo method. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO₂ emission factors for substitute fuels, along with the relevant

uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

The activity data for the new German Länder, for base year 1990 and the following years, 1991-1994, were adjusted in keeping with findings from the pertinent research project (FKZ 205 41 115 / Sub-project A "Revision and substantiation of fuel inputs for stationary combustion systems in the new German Länder for the year 1990"). The relevant recalculation method is described in the Annex, Chapter 19.1.2.1.

3.2.9.10.4 Source-specific quality assurance / control and verification (1.A.2.f, Lime production)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

In the research project "Inputs of secondary fuels" (UBA 2005b, FKZ 204 42 203/02), the time series for data on substitute-fuel inputs in the lime industry were also intensively checked for consistency and plausibility. To those ends, the industry's entire energy and emissions situation was considered – i.e. the same procedure was used that has been applied to other economic sectors with substitute-fuel inputs. Such quality assurance is subject to the constraint that the relevant data provided by the Bundesverband Kalk lime-industry association begin with the year 2003, however.

The data obtained fit with the overall picture for the sector, in light of relevant other fuel consumption and the pertinent CO₂ emissions.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.10.5 Source-specific recalculations (1.A.2.f, Lime production)

For this source category, this year recalculations were carried out for the year 2008, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance. The following changes result:

Solid fuels: + 338,028 t CO₂
 Liquid fuels: - 41,558 t CO₂
 Gaseous fuels: - 76,125 t CO₂

3.2.9.10.6 Source-specific planned improvements (1.A.2.f, Lime production)

No improvements are planned at present.

3.2.9.11 Manufacturing industries and construction - Other energy production (1.A.2.f, Other)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	NE	NE				NE				
Distribution of uncertainties										
EF-determination method	CS	CS				CS				

As a result of its function as a collective category for fuel inputs that cannot be disaggregated to the individual-sector level, this sub- source category is particularly significant; it contributes substantially to the entire energy sector's CO₂ emissions.

3.2.9.11.1 Source category description (1.A.2.f Other)

In this sub- source category, all those emissions are reported for which the relevant energy inputs cannot be disaggregated in keeping with the categories in 1.A.2. This sub- source category is responsible for about $\frac{3}{4}$ of all CO₂ emissions of source category 1.A.2. When emissions from use of biomass in process combustion are not included, its share becomes even larger.

All heat and power generation in industrial power stations and boiler systems is listed in this sub- source category. All energy-related emissions from the chemical industry are also reported in it. No specific data are assigned to the structural element "Other process combustion". A large part of the energy inputs listed in 1.A.2.f Other should really be allocated to the various corresponding sectors, but the available data do not permit such allocation. Since no delivery data are available for the gases in source category 1.A.2, these gases cannot be assigned to the various individual processes. They are thus reported here in sum form.

3.2.9.11.2 Methodological issues (1.A.2.f Other)

The fuel inputs for electricity generation in industrial power stations are shown in Energy Balance line 12. The difference resulting after deduction of the fuel inputs for refinery power stations, mine power stations, power stations in the hard-coal-mining sector and, for the period until 1999, for the power stations of Deutsche Bahn (German Railways) consists of the activity data for other industrial power stations. These data cannot be further differentiated.

Additional data from the Federal Statistical Office are needed for allocation of fuel inputs to heat production in industrial power stations and boiler systems. Fuel inputs for heat production in CHP systems can be determined from relevant statistics. The activity data for boiler systems are calculated as the pertinent difference.

For both electricity production and heat production, gas turbines, gas and steam systems and gas engines are differentiated.

A detailed description of the relevant calculation algorithms, which were extensively revised for the 2008 reporting year, is provided in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132).

With the new data source "BGS-Bogen" ("BGS form; see above), it has become possible to list, separately, use of top gas for energy production in live-steam boilers in the iron and steel industry.

The total energy quantity listed in Energy Balance line 54 (metal production), for use of top gas, is lower than the total top-gas input as shown by the BGS data (see above). The thusly underestimated input quantity is assigned, by definition, to part of the relevant flaring and line losses.

In general, as of report year 2011, CO₂ emissions from top-gas combustion in industrial power stations and boilers are reported in source category 1.A.2.f. The following table provides an overview of CO₂ emissions from top-gas combustion, throughout the entire time series:

CO ₂ emissions from top-gas combustion in industrial power stations [millions of t of CO ₂]									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
21.043	19.639	19.823	18.403	18.526	19.431	15.489	17.005	17.896	16.857
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
16.500	13.567	15.337	11.657	11.643	14.432	15.406	20.395	18.698	14.814

Emission factors (except for CO₂-emission factors)

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in source category 1.A.2f / all other, have been taken from RENTZ et al (2002). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The research project breaks down the relevant sector into power stations of Deutsche Bahn AG, other industrial power stations and other boiler combustion systems for production of steam and hot/warm water.

3.2.9.11.3 Uncertainties and time-series consistency (1.A.2.f Other)

Activity data

The uncertainties were determined, for the first time, for 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

Emission factors

The procedure for determining uncertainties is described in Chapter 3.2.6.3.1.

Result for N₂O: The results of Chapter 3.2.6.3.2 apply mutatis mutandis.

Result for CH₄: The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

The results obtained in Chapter 3.2.6.3.4 in determination of time-series consistency apply mutatis mutandis.

3.2.9.11.4 Source-specific quality assurance / control and verification (1.A.2.f Other)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

Activity data

The quality of the data was reviewed in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132) and improved via use of statistics of the Federal Statistical Office as a database. No other data sources with long-term availability have been identified.

Emission factors

The results obtained in Chapter 3.2.6.4, in the general procedure for source-specific quality assurance / control and verification, apply mutatis mutandis.

3.2.9.11.5 Source-specific recalculations (1.A.2.f Other)

Activity data

In keeping with the calculation method used, and the recalculations carried out for the iron and steel industry, new recalculations were carried out for the period as of 1990. The following table provides an overview of the recalculations as of 1990:

Table 34: Recalculations for CO₂ in CRF 1.A.2.f Other

Year	Solid fuels	Liquid fuels	Gases	Other	Total
	[t CO ₂]	[t CO ₂]	[t CO ₂]	[t CO ₂]	[t CO ₂]
1990	17,299,848	-212,615	-946,004	0	16,141,229
1991	15,483,047	-326,079	-1,012,492	0	14,144,476
1992	15,862,639	-265,317	-713,909	0	14,883,413
1993	14,747,105	-198,458	-678,129	0	13,870,518
1994	14,840,177	-103,311	-652,450	0	14,084,416
1995	13,290,143	-136,765	-495,779	0	12,657,599
1996	10,624,697	-188,607	-471,335	0	9,964,756
1997	13,067,489	-180,718	-433,192	0	12,453,579
1998	15,382,727	-134,165	-406,664	0	14,841,898
1999	14,069,062	-84,487	-341,807	0	13,642,768
2000	10,115,701	-76,193	-447,744	0	9,591,764
2001	9,797,858	175,529	-541,400	0	9,431,986
2002	11,973,248	-170,970	-398,664	0	11,403,613
2003	5,874,136	294,215	-155,639	4,080	6,016,791
2004	3,731,210	236,462	-113,467	17,460	3,871,665
2005	7,292,024	438,683	-123,850	24,960	7,631,817
2006	7,866,966	-55,158	-166,163	85,200	7,730,845
2007	11,257,679	70,993	267,794	338,628	11,935,095
2008	12,627,894	-550,404	-2,234,402	2,862,874	12,705,962

Recalculations on the basis of the in-country review 2010 are presented in Chapter 10.5.2.

Emission factors:

The results of Chapter 3.2.6.5 apply mutatis mutandis.

3.2.9.11.6 Source-specific planned improvements (1.A.2.f Other)

Activity data:

No improvements are planned at present.

Emission factors:

The new research projects, as described in Chapter 3.2.6.6, for updating of emission factors (except for those for CO₂) will also cover power stations and other combustion systems in the area of "manufacturing - other energy production".

3.2.10 Transport (1.A.3)

3.2.10.1 Transport - Civil aviation (1.A.3.a)

3.2.10.1.1 Source category description (1.A.3.a)

CRF 1.A.3										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions			2009 – contribution to total emissions			Trend	
		- / -								
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	--	--	--	CS	CS	CS	CS	CS
EF uncertainties in %	±5	-57 / +100				-70 / +150				
Distribution of uncertainties	N	L				L				
EF-determination method	T2	T3	--	--	--	T3				

The source category *Civil aviation* is not a key source.

Air transports differ significantly from land and water transports with respect to emissions production. In air transports, fuels are burned under atmospheric conditions that a) differ markedly from those prevailing at ground level and b) can vary widely. The main factors that influence the combustion process in this sector include atmospheric pressure, environmental temperature and humidity – all of which are factors that vary considerably with flight altitude.

In addition to considering carbon dioxide, the debate on the climate effects and airborne-emissions-related environmental impacts of air transports focuses mainly on water vapour and nitrogen oxides and, secondarily, on hydrocarbons, particulates, carbon monoxide and sulphur dioxide. In the framework of national emissions reporting, figures for other emissions are also required, however. The following remarks thus refer to emissions of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O – laughing gas), nitrogen oxides (NO_x, i.e. NO and NO₂), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO₂), HC (hydrocarbons), dust (total suspended particles; TSP) and ammonia (NH₃).

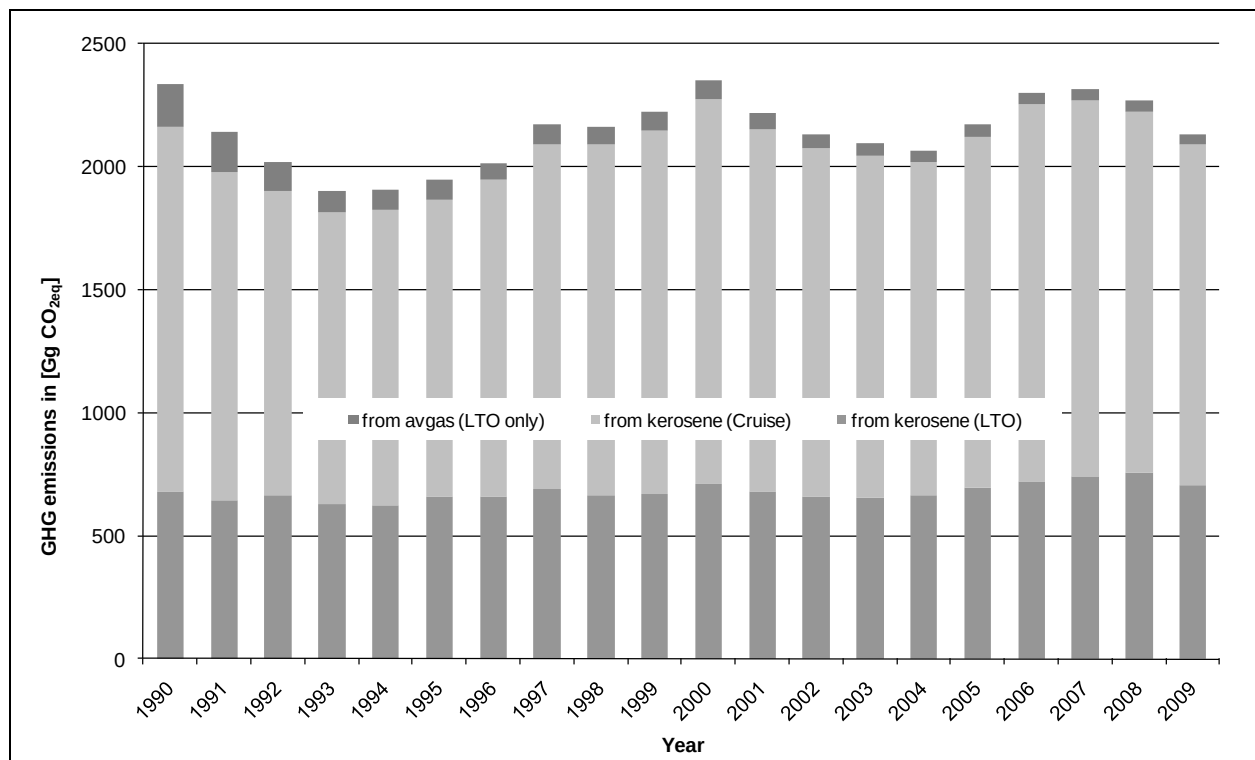


Figure 30: Development of greenhouse-gas emissions in national air transports, 1990 – 2009

3.2.10.1.2 Methodological issues (1.A.3.a)

This year, air-transport emissions are being calculated for the first time in accordance with Tier 3a, i.e. taking account of the annual flight mileages logged by the relevant individual aircraft types, broken down by national and international flights, and taking account of the operational states LTO cycle (landing/take-off cycle, i.e. aircraft movements to an elevation of 3,000 feet / about 915 m) and cruise.

In general, emissions are determined on the basis of the Energy Balance data for consumption of kerosene and aviation gasoline (AGEB, 2010). For years for which no data are yet available, data of the Federal Office of Economics and Export Control (BAFA, 2010) are used. The manner in which national and international air transports are differentiated plays a decisive role in reporting. The differentiation is achieved via a "split factor" that describes national kerosene consumption as a share of total kerosene consumption. For the first time this year, the split factor for the years 1990 through 2002 has been determined with the help of research-project findings oriented to the mileage, expressed in terms of great-circle distances, flown by the various different types of aircraft (FKZ 360 16 029 – Implementierung eines eigenständigen Moduls zur Berechnung des Flugverkehrs in das bestehende TREMOD-System ("Implementation, within the existing TREMOD system, of a separate module for calculations oriented to air transports"; IFEU & ÖKO-INSTITUT 2010)). The relevant data are collected by the Federal Statistical Office. For the period as of 2003, data provided by Eurocontrol are used, in keeping with the procedure followed in past years. Using the ANCAT model, Eurocontrol calculates fuel consumption on the basis of individual aircraft movements. It does not cross-check fuel consumption against national Energy Balances, however.

For breakdown of kerosene consumption by the LTO and cruise phases, the results of calculations made in TREMOD, on the basis of data of the Federal Statistical Office, are used.

For reporting purposes, emissions are determined, in each case, by multiplying fuel consumption for the relevant flight phase by the pertinent specific emission factor. CO₂, H₂O and SO₂ emissions figures do not depend on what Tier method is used; they depend solely on quantities and characteristics of consumed fuel. Emissions of NMVOC, CH₄, CO, HC, NO_x and N₂O, on the other hand, depend on engines, flight altitudes, flight phases, etc., and thus they are described more precisely by higher-Tier methods. The emission factors for NO_x, CO and HC are thus taken from the results of the TREMOD calculations.

Since 2007, figures for the relevant gasoline consumed (aviation gasoline) are no longer reported together with figures for consumed jet kerosene; they are reported separately. As proposed in IPCC 2006a, emissions from consumption of aviation gasoline are calculated separately, with adapted emission factors and net calorific values, pursuant to the Tier 1 method. In such calculation, there is no need for any breakdown into national and international transports; aviation gasoline is used only in smaller aircraft that fly mostly domestic routes. That understanding functions as a conservative assumption; it leads to slight overestimation of national emissions.

Activity data:

Aviation turbine fuel / jet kerosene

The relevant consumption data accord with the figures for aviation fuel consumed in Germany, pursuant to the national Energy Balance (the latest version, covering the period until 2008) and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (for 2009) (AGEB, 2010; BAFA, 2010).

For the present purposes, jet-kerosene-consumption figures from the Energy Balance and from BAFA statistics have to be broken down by national and international flights. Until 2007, this breakdown was carried out using a constant value of 20 %, in keeping with a pertinent study of the TÜV Technical Inspection Association from 1989 (UBA, 2001a). Since 2007, revised assumptions pursuant to ÖKO-INSTITUT (2009) are used for reporting purposes, with use of Eurocontrol data, available as of 2003, for the breakdown into national and international flights.

The results of the current research project now make it possible to revise the factor again: the calculations with the expanded TREMOD model take account of the numbers of flights, for the various aircraft types and great-circle distances involved, for national and international air transports. In the process, the commercial flights recorded by the Federal Statistical Office, for certain airports, are included. The Federal Statistical Office differentiates the other types of flights concerned (at other airports, and non-commercial flights) only by weight classes or aircraft classes, however; it does not differentiate them by destination. The great majority of the relevant commercial flights at other airports are flights by small aircraft fuelled with aviation gasoline. The relevant share of such aircraft types is higher in the non-commercial category, which also includes balloons and motorised gliders. Rough calculations pursuant to IFEU & ÖKO-INSTITUT (2010) indicate that it is appropriate to allocate all such flights to (solely national) avgas consumption.

Using figures for actual take-offs, pursuant to data of the Federal Statistical Office (and broken down by aircraft types and great-circle distances), using specific consumption factors for the different aircraft types and flight phases involved and applying a detour factor, a considerably lower share of domestic flights results for the years through 2002. For reasons of international comparability, the data available from Eurocontrol are to be used for the period as of the year 2003. In order to harmonise the data series in 2003, a slight-correction factor was applied to the calculations pursuant to TREMOD. The results are compared in the following figure.

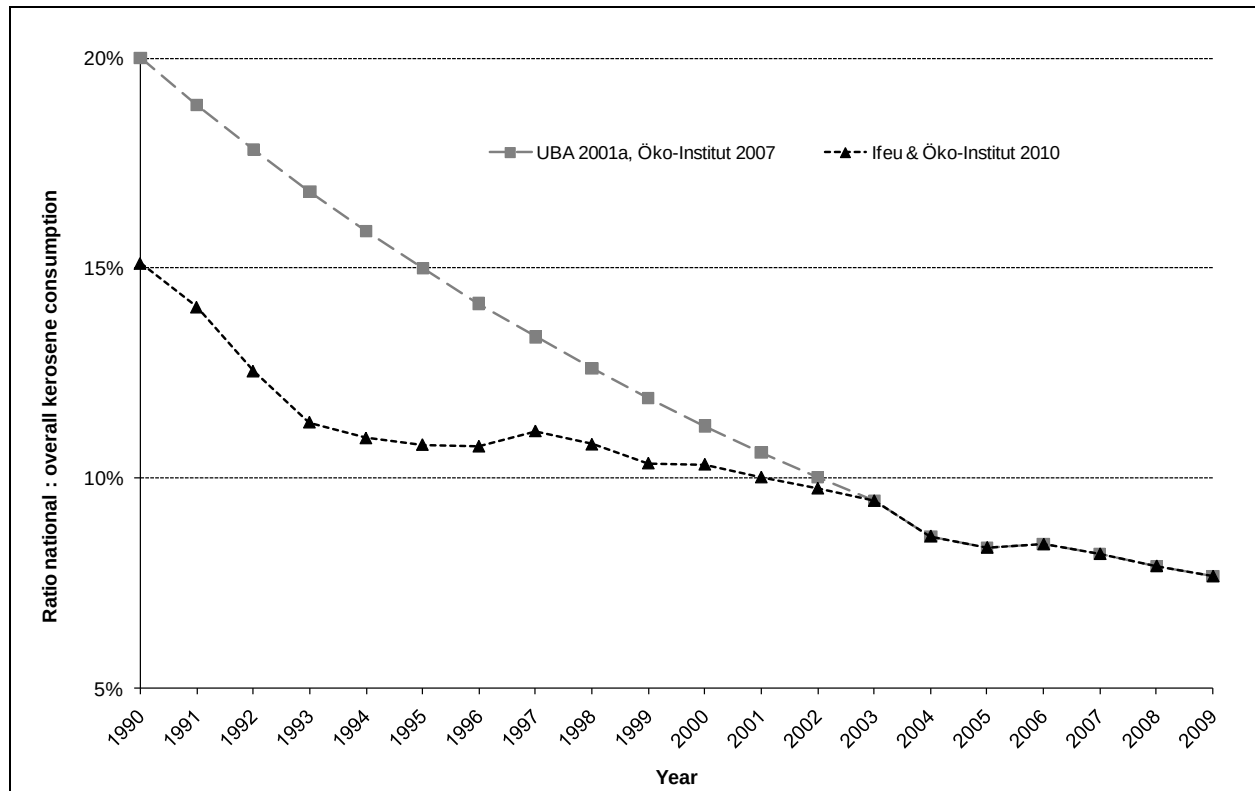


Figure 31: Revised split factor for national/international air traffic, 1990-2009

Table 35: Development of the national share since 1990 - pursuant to IFEU & ÖKO-INSTITUT 2010

Year	1990	1995	2000	2003	2004	2005	2006	2007	2008	2009
National share [%]	15.1	10.8	10.3	9.5	8.6	8.3	8.4	8.2	7.9	7.7

Jet-kerosene consumption is broken down, in accordance with the two flight phases *LTO* and *cruise*, with the help of the results of TREMOD calculations. Those results make it possible to divide kerosene consumption figures for the LTO flight phase (cf. IFEU & ÖKO-INSTITUT, 2010) by national and international air traffic. Consumption in the cruise-flight phase then results, in each case, as the difference between kerosene consumption pursuant to the Energy Balance and consumption in the LTO phase.

Avgas

The relevant consumption data accord with the figures for aviation fuel consumed in Germany, pursuant to the national Energy Balance (the latest version, covering the period until 2008) and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (for 2009) (AGEB, 2010; BAFA, 2010). In a conservative approach, all

relevant consumption is assumed to occur in national flight operations. Pursuant to IPCC 2006a, breakdown by LTO and cruising flight phases is not required.

Lubricants

In the present report, quantities of co-combusted lubricants, and the resulting CO₂ emissions, have been determined and reported for the first time (cf. the recalculations below). The figures for annual inputs of lubricants in air transports are taken from the official mineral-oil statistics (Amtliche Mineralölstatistik) of BAFA, and the co-combusted fraction is determined via expert assessment.

Emission factors:

Aviation turbine fuel / jet kerosene

Emissions are calculated separately by flight phases, on the basis of the relevant emission factors. In the process, different sources are used. In contrast to the procedure used in previous reports, emissions of NO_x, CO and HC are now based on aircraft-type-specific emission factors stored in TREMOD. With this detailed calculation, average emission factors are formed that are then used for reporting purposes.

The emission factor for *carbon dioxide* was derived on the basis of the carbon content of jet kerosene. The average *emission factor for carbon dioxide from jet kerosene* is thus 3,150 g/kg. That value has been confirmed in numerous publications (including IPCC, 1999: p. 3.64), and it is used, without any changes, for all flight operations (national/international; LTO/cruise).

Nitrous oxide (laughing gas) is a product of nitrogen oxidation in the combustion chamber, and it can occur in traces. The available data for this substance are poor. Since the emission factors have to be broken down in accordance with the two flight phases, the emission factors for both nitrous oxide and *methane* have been taken from the IPCC emission factor database (cf. Table 289). The emissions per LTO cycle are recalculated using standard values for jet-kerosene consumption per LTO cycle: For national flight operations, the relevant figure is 850 kg jet kerosene / LTO, while for international flight operations an average value of 1,675 kg kerosene / LTO cycle is assumed (IPCC 2006b). Figures relative to the air pollutants additionally considered are presented in Chapter 19.1.3.1 in the Annex.

For reporting purposes, annual average emission factors for the entire fleet are derived from the emissions calculated with TREMOD. The results differ from the corresponding previously used values.

The relevant emission factors were converted from [kg emissions / kg of burned fuel] to [kg emissions / TJ converted energy]; the conversion factor used for this, for all relevant years, was the pertinent net calorific value, 43,000 kJ/kg.

Avgas

Pursuant to IPCC 2006a, no differentiation by LTO cycle and cruise phase is required for avgas. For this reason, no corresponding differentiation of emission factors was carried out. As was done for the EF for kerosene, the emission factors for NO_x, CO und HC were obtained from the results of TREMOD calculations. For calculation of total NO_x, CO and HC emissions from avgas, the aircraft-type-specific emission factors from the EMEP-EEA

database were used. Those factors were then divided by the relevant avgas consumption, to obtain annual, average emission factors for reporting purposes.

For purposes of calculation of *CO₂ emissions*, the standard value pursuant to the *IPCC Guidelines* (2006a) is used. In those guidelines (page 3-64), the emission factors for methane and nitrous oxide are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here – along with the forecasts for jet-kerosene use in cruise phases of national air transports (cruise phase in 2008).

All emission factors are listed in Table 36.

Table 36: Emission factors for avgas (1990-2009)

Gas	Emission factor [g/kg]	Remarks regarding the source or calculation
CO ₂	3,018.00	from IPCC Guidelines 2006, Table 3.6.4
CH ₄	0.36	same as EF kerosene, LTO/national/2008
N ₂ O	0.10	same as EF kerosene, cruise/national/2008

Source: Öko-Institut (2009)

The relevant emission factors were converted from [kg emissions / kg of burned avgas] to [kg emissions / TJ converted energy]; the conversion factor used for this was the pertinent net calorific value, 44,300 kJ/kg.

Lubricants

The CO₂ emissions from co-combustion of lubricants, which in the present report are being listed for the first time, were calculated via an IPCC default-EF of 80,000 kg/TJ. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

3.2.10.1.3 Uncertainties and time-series consistency (1.A.3.a)

For determination of uncertainties, the individual components that enter into emissions calculation are identified, and their uncertainties (U_1 to U_n) are quantified. Pursuant to to IPCC GPG (2000), the total uncertainty U_{total} is obtained via additive linking of squared partial uncertainties, in accordance with the following formula:

$$U_{\text{ges}} = \sqrt{U_1^2 + U_2^2 + \dots + U_n^2}$$

For all time series and flight phases, uncertainties were estimated as mean values. The total uncertainties were calculated as is shown in Annex Chapter 19.1.3.1.2. The left column contains the components that enter into the uncertainty calculation; the relevant partial uncertainties are listed in the neighbouring columns to the right. The columns that then follow to the right contain the values for the required total uncertainties. Some of these, in turn, are individual components of the uncertainties calculation for other values. For example, the uncertainty for national jet-kerosene consumption in the two relevant flight phases, LTO and cruise, is calculated from the partial uncertainties for total national jet-kerosene consumption and from the partial uncertainty for the LTO/cruise differentiation. The latter of these partial uncertainties is based on the number of relevant flights, pursuant to the *Federal Statistical Office*, as well as on assumptions pertaining to relevant fleet divisions (in national flight

operations, an average consumption of 850 kg jet kerosene per LTO cycle is applied, in keeping with the IPCC's assumptions). The total uncertainty for jet-kerosene consumption during the LTO and cruise flight phases, in turn, serves as a partial uncertainty in determination of the uncertainties for emissions data.

Some partial uncertainties are based on assumptions. For example, one uncertainty for the entire time series for the split factor for dividing national and international flights is given as an average throughout the time series. For the years 1990 through 2002, the data are based on the TREMOD calculation, which, in turn, is based on the relevant data of the Federal Statistical Office, on the emission factors in the EMEP-EEA database and on calculations of our own. For the years 2003 to 2009, the pertinent Eurocontrol data are used, data which were calculated with the ANCAT model. Comparisons of random samples of a) results obtained with the ANCAT model and b) actual consumption data show deviations of $\pm 12\%$. Eurocontrol data obtained with the AEM 3 model had an uncertainty of only 3 to 5 % (EUROCONTROL 2006).

3.2.10.1.4 Source-specific quality assurance / control and verification (1.A.3.a)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The Single National Entity's additional quality assurance remains to be carried out.

The current calculation procedures have been verified on the basis of more-current data and findings. This applies to the various emission factors used and the energy-content figures required for conversion into energy-related emission factors.

For determination of emissions from air transports, emission factors used to date had to be revised and adjusted to take account of recent information, technological progress in aircraft engines and a new calculation method. Basically, calculation of greenhouse-gas emissions is based on data of the Energy Balance and on emission factors pursuant to the IPCC-Guidelines. Air transports are divided into national and international air transports, via the split factor, in keeping with the results of TREMOD calculations (for the years 1990-2002) and with the relevant figures of Eurocontrol (as of 2003). In addition, the breakdown into the two flight phases, and the emission factors for NO_x, HC and CO, result from the TREMOD calculations. Those calculations are based on data of the Federal Statistical Office, as well as on aircraft-type-specific data taken from the EMEP-EEA database. For a certain share of aircraft types, a share that has been increasing over time, emission factors have to be obtained via regressions carried out on the basis of take-off weight. Use of more current, and more complete, aircraft-type-specific data would further improve the quality of the calculations. Furthermore, expansion of the TREMOD calculations, to include differentiation in accordance with the different engines used, would also improve the quality of the calculations.

Except for the emission factors for sulphur dioxide, international standard values were used, taken from the IPCC emission-factors database, the EMEP-EEA database or the Corinair Guidebook (2006). Discussions of the various individual values are presented in the "Methodological Aspects" chapters of the presentations of the various emission factors.

3.2.10.1.5 Source-specific recalculations (1.A.3.a)

Because the split factor has been recalculated, transports have been broken down into flight phases and fleet-specific average emission factors for NO_x, CO and HC have been used, all air-transport emissions have been recalculated.

Findings from the above-described research project have led to changes in the split factor for breakdown of statistically recorded total kerosene consumption by national and international flights, for the years through 2002. The changes are presented in Table 37. The national share of jet-turbine fuel (kerosene) sold has decreased continuously, from 15.1 % in 1990 to 7.7 % in 2008. The pertinent emissions share has also decreased as a result.

Table 37: Revision of the split factor for national transports as a share of total transports, 1990-2002

Split factor for national transports as a share of total air transports	Units	1990	1991	1992	1993	1994	1995	1996
Resubmission 2010	[%]	20.00	18.88	17.82	16.82	15.88	14.99	14.15
Submission 2011		15.11	14.07	12.54	11.33	10.95	10.79	10.75
Absolute difference		-4.89	-4.81	-5.28	-5.50	-4.93	-4.20	-3.40
Relative difference		-24.43	-25.47	-29.62	-32.68	-31.06	-28.02	-24.03
Split factor for national transports as a share of total air transports	Units	1997	1998	1999	2000	2001	2002	2003
Resubmission 2010	[%]	13.36	12.61	11.91	11.24	10.61	10.02	9.46
Submission 2011		11.12	10.80	10.35	10.32	10.02	9.75	9.46
Absolute difference		-2.24	-1.81	-1.56	-0.92	-0.59	-0.27	0.00
Relative difference		-16.79	-14.37	-13.07	-8.16	-5.60	-2.65	0.00

For nearly all years, corrections – in part, only minimal – in total kerosene consumption, and thus in the partial-consumption figures applying separately to national and international flights, were required.

Table 38: Revision of kerosene consumption of total air transports leaving from German airports

Kerosene consumption	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Resubmission 2010	[TJ]	194,704	190,920	205,798	216,548	225,148	233,447	244,627	253,829	261,182	280,231
Submission 2011		193,329	189,610	204,386	216,548	225,148	233,437	244,610	253,849	261,185	280,244
Absolute difference		-1,375	-1,310	-1,412	0	0	-10	-17	20	3	13
Relative difference		-0.71	-0.69	-0.69	0.00	0.00	-0.004	-0.007	0.008	0.001	0.005
Kerosene consumption	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Resubmission 2010	[TJ]	297,259	289,777	287,412	291,827	298,779	343,827	361,233	374,428	378,346	-
Submission 2011		297,258	289,768	287,394	291,827	316,211	343,827	361,233	374,428	380,114	368,951
Absolute difference		-1	-9	-18	0	17,432	0	0	0	1,768	-
Relative difference		-0.0003	-0.003	-0.006	0.00	5.83	0.00	0.00	0.00	0.47	-

In addition, in the present report, CO₂ emissions from co-combustion of lubricants have been recorded and reported for the first time. The following table provides an overview of the calculated co-combusted quantities and the resulting CO₂ emissions.

Table 39: Trends for lubricants co-combusted in category 1.A.3.a, and the resulting CO₂ emissions (now being reported for the first time) as of 1990

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Energy input	[TJ]	2.34	1.65	1.14	1.14	1.01	0.92	0.69	0.56
CO₂ emissions	[Gg]	0.19	0.13	0.09	0.09	0.08	0.07	0.05	0.04

The effects of all described changes, in the database underlying the emissions calculations, on reported total greenhouse-gas emissions in the source category are summarised in the following table.

Table 40: Effects of described revisions of the inventory on reported greenhouse-gas emissions, 1990-2008

Greenhouse-gas emissions (1.A.3.a)	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Resubmission 2010	[Gg CO ₂ -equiv.]	3,054.6	2,837.6	2,835.6	2,783.7	2,730.8	2,672.4	2,630.7	2,593.6	2,512.4	2,549.4
Submission 2011		2,335.6	2,144.5	2,018.7	1,902.7	1,908.8	1,946.7	2,015.0	2,172.4	2,161.9	2,226.5
Absolute difference		-718.9	-693.0	-816.9	-881.0	-822.0	-725.7	-615.7	-421.2	-350.5	-322.8
Relative difference	[%]	-23.54	-24.42	-28.81	-31.65	-30.10	-27.16	-23.41	-16.24	-13.95	-12.66
Greenhouse-gas emissions (1.A.3.a)	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Resubmission 2010	[Gg CO ₂ -equiv.]	2,553.5	2,346.7	2,190.5	2,098.1	1,953.2	2,173.1	2,298.6	2,313.9	2,258.8	-
Submission 2011		2,351.4	2,219.0	2,133.5	2,097.8	2,064.0	2,172.9	2,298.5	2,314.0	2,269.3	2,134.0
Absolute difference		-202.1	-127.8	-57.0	-0.3	110.8	-0.3	-0.1	0.02	10.4	-
Relative difference	[%]	-7.91	-5.44	-2.60	-0.01	5.67	-0.01	-0.005	0.001	0.46	-

3.2.10.1.6 Source-specific planned improvements (1.A.3.a)

The Federal Environment Agency continues to seek an agreement with Eurocontrol regarding the provision of original Eurocontrol data.

As soon as Eurocontrol provides data from the AEM 3 model, such data can be used in reporting. With such data, the applicable share for national air transports, the breakdown of kerosene consumption by the two relevant flight phases and NO_x, HC and CO emissions data would all be based on calculations pursuant to Tier 3b.

3.2.10.2 Transport – Road transport (1.A.3.b)

3.2.10.2.1 Source category description (1.A.3.b)

CRF 1.A.3.b					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	I / t / T2	CO ₂	12.31 %	15.41 %	-3.8 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS/M	-	-	-	CS/M	CS/M	CS/M	CS/M	CS/M
EF uncertainties in %	±7	-72 +110	-	-	-	-76 +181				
Distribution of uncertainties	N	L/N	-	-	-	L/N				
EF-determination method	T2	T3	-	-	-	T3				

The source category *Road transport* is a key source of CO₂ emissions in terms of both emissions level and trend.

Emissions from motorised road traffic in Germany are reported under this category. It includes traffic on public roads within Germany, except for agricultural and forestry transports and military transports. Calculations are made for the vehicle categories of passenger cars, motorcycles, light duty vehicles, heavy duty vehicles and buses. For calculation purposes, the vehicle categories are broken down into so-called *vehicle layers* with the same emissions behaviour. To that end, vehicle categories are also broken down by type of fuel used, vehicle size (trucks and buses by weight class; automobiles and motorcycles by engine displacement) and pollution control equipment used, as defined by EU directives for emissions control ("EURO norms"), and by regional traffic distribution (outside of cities, in cities and on autobahns).

3.2.10.2.2 Methodological issues (1.A.3.b)

Since 1990, emissions of CH₄, NO_x, CO, NMVOC and SO₂ from road transports have decreased sharply, due to catalytic-converter use and engine improvements resulting from continual tightening of emissions laws, and due to improved fuel quality.

Between 1990 and 1993, the methane emission factor for petrol dropped sharply, producing a corresponding sharp reduction in methane emissions. This was due especially to a massive reduction in the numbers of vehicles with two-stroke engines in the new German Länder. Further EF decreases have resulted via the aforementioned tightening of emissions standards.

For buses and heavy duty vehicles (over 3.5 t total permissible vehicle weight), maximum permissible levels of hydrocarbon (HC) emissions were lowered considerably (-40 %) via the introduction of the EURO3 standard in 2000. Since EURO3 vehicles were very quick to reach the market as of 2000, the emission factor for hydrocarbon emissions from diesel fuel – and the relevant emissions themselves – decreased considerably after 2000. A similar trend occurred for methane, emissions of which are calculated as a fixed share of total HC emissions.

N₂O emissions result primarily from incomplete reduction of NO to N₂ in 3-way catalytic converters. They are not limited by law. Initially, growth in numbers of cars with catalytic converters caused increases in N₂O emissions in comparison to the 1990 level. Newer catalytic converters are optimised to produce only small amounts of N₂O, however. For this

reason, the decreasing trend in N₂O emissions that has been observed since 2000 can be expected to continue.

CO₂ emissions depend directly on fuel consumption. From 1990-1999, these emissions increased, since growth in mileage travelled outweighed improvements in vehicle fuel consumption. Prior to the year 2000, CO₂ emissions showed only an increasing trend in the transport sector. Since that year, a first marked trend reversal has been seen, however. In 2009, fossil-fuel emissions were 26.6 million t lower than they were in 2000. The likely reasons for this trend include reductions in specific fuel consumption, the marked shift toward diesel vehicles in new registrations, continual increases in fuel prices, use of biofuels – and consumers' growing tendency to travel to other countries in order to make their fuel purchases (see the following paragraphs).

Table 41: Emissions from road transports

	CO ₂		CH ₄	N ₂ O	NO _x	CO	NMVOC**	SO ₂
	fossil	bio*						
	[Gg]							
1990	150,358.32	0.00	60.53	1.96	1,341.45	6,527.26	1,408.97	90.20
1995	165,104.05	106.48	30.34	4.63	1,146.56	3,822.97	593.00	69.31
2000	171,229.50	869.14	15.68	4.82	1,004.04	2,452.83	278.59	19.67
2005	151,603.51	5,573.72	8.76	3.76	707.03	1,549.74	154.67	0.81
2006	147,747.28	10,179.93	8.14	3.56	704.16	1,420.86	143.28	0.82
2007	145,034.69	11,034.17	7.29	3.37	651.84	1,305.11	130.33	0.81
2008	144,844.73	8,950.72	6.64	3.13	592.21	1,215.28	120.10	0.81
2009	144,615.51	8,101.05	6.27	3.03	551.19	1,143.13	115.39	0.83

*) CO₂ emissions from biofuels are listed here solely for informational purposes.

**) includes evaporation-related emissions

CO₂ emissions from motorised road transports in Germany are calculated via a "bottom-up" approach (Tier 2 approach pursuant to IPCC GPG, 2000: p. 2.46): In the pertinent process, the fuels sold in Germany (petrol, (bio-) ethanol fuel, diesel fuel, biodiesel, LP and natural gas, petroleum (until 2002)) are allocated, within the TREMOD ("Transport Emission Model") model, to the various relevant vehicle layers (cf. Chapter 19.1.3.2). The consumption data that enter into the model, for each type of fuel, are obtained from the *Energy Balances*. CO₂ emissions are calculated – following import of the layer-specific fuel consumption figures – using country-specific emission factors from the CSE.

Non-CO₂ emissions are calculated with the aid of the TREMOD model (IFEU, 2010)¹⁸. That model incorporates a Tier-3 approach whereby mileage of the individual vehicle layers is multiplied by specific emission factors. For passenger cars and light duty vehicles, a "cold start surplus" is also added. The total consumption determined for each fuel type is cross-checked against consumption pursuant to the Energy Balance. Then, the relevant emissions are corrected with the help of factors obtained via such cross-checking. For petrol-powered vehicles, the evaporation emissions of VOC are calculated in keeping with the pollution-control technology used.

From the emissions and fuel-consumption figures for the various vehicle layers, aggregated, fuel-based emission factors (kg of emissions per TJ of fuel consumption) are derived and

18 To make it possible to derive and assess reduction measures, energy consumption and CO₂ emissions for the various vehicle categories are also calculated with TREMOD. The resulting values are subsequently checked against total consumption and total CO₂ emissions.

then forwarded to the CSE database. In keeping with the CORINAIR report structure, these factors are differentiated only by type of fuel, type of road (autobahn, rural road, city road) and, within the vehicle categories, by "without/with emissions-control equipment". The following emissions-control categories are differentiated:

Table 42: Differentiation of emissions-control categories in road transports

	Emissions-control system	
	Without	With
Passenger cars / light commercial vehicles with petrol-burning engines	Without catalytic converter	With catalytic converter
Passenger cars / light duty vehicles with diesel engines, buses, heavy duty vehicles, motorcycles	Before Euro 1 standard	As of Euro1 standard

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys have been used, co-ordinated, and supplemented. An overview of the principal sources and key assumptions is given below. Detailed descriptions of the databases, including information on the sources used, and the calculation methods used in TREMOD, are provided in the aforementioned IFEU report.

Motor-vehicle-fleet data:

For western Germany from 1990 through 1993, and for Germany as a whole as of 1994, car ownership was calculated on the basis of the officially published ownership and new registration statistics of the Federal Motor Transport Authority (KBA). The car ownership analysis for East Germany in 1990 was based on a detailed analysis of the Adlershof car-emissions-testing agency in 1992 and the time series in the statistical annuals of the GDR. For the period between 1991 and 1993, it was necessary to estimate the figures with the aid of numerous assumptions.

Fleet data for the TREMOD model, as of reference years as of 2001, is the result of cross-checking with the database of the Federal Motor Transport Authority (KBA). The supplied data include vehicle fleets for each reference year, broken down as required for emissions calculation, i.e. in accordance with the following characteristics: type of engine (petrol, diesel, other), size class, vehicle age and emissions standard. For each reference year, the mid-year fleet is assumed to be representative of the fleet's composition for the year.

Emission factors:

All emission factors are listed in the "Emission-factor manual for road transports 2.1" ("Handbuch für Emissionsfaktoren des Straßenverkehrs 1.2") (INFRAS, 2004), a reference work prepared via co-operation, between Germany, Switzerland, Austria and the Netherlands, in derivation of emission factors for road traffic. The emission factors in the manual originate predominantly from the measurement programmes of TÜV Rheinland (TÜV = Technical Control Association) and RWTÜV. Those programmes have included fundamental surveys for the reference years 1989/1990. In those surveys, a new method was used, for both passenger cars and heavy duty vehicles, whereby emission factors were derived on the basis of driving habits and traffic situations. Emission factors for automobiles until the 1994 (automobile-)model year were updated with the help of field-monitoring data. Version 2.1 of the "Emission-factor manual for road transports", which is used for the current emissions calculations, draws on findings of the EU working group COST 346 and the ARTEMIS research programme.

The emission factors are derived from the development of the various vehicle layers and from the data provided by the "Emission-factor manual for road transports 2.1". The

emissions reduction achieved via the introduction of sulphur-free fuels was estimated by the Federal Environment Agency.

For the country-specific emission factors for CO₂, the reader's attention is called to the documentation in Annex 2, Chapter CO₂ emission factors. For bioethanol, the value used for gasoline, 72,000 kg/TJ, is used, while an IPCC default value of 70,800 kg/TJ is used for biodiesel. An IPCC default value is also used for CO₂ from co-combusted lubricants: 80,000 kg/TJ. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Mileage data:

Mileage data were updated on the basis of the "2002 mileage survey" ("Fahrleistungserhebung 2002"; Institute of Applied Transport and Tourism Research (IVT) 2004), the "2005 road-transport census" ("Straßenverkehrszählungen 2005"; Federal Highway Research Institute (BASt), 2007) and data on growth of transports on federal highways (BASt, 2008).

Shifting of fuel purchases to other countries

Because fuel prices in Germany are higher – significantly, in some cases – than in almost all of Germany's neighbours, for some time the fuels used in Germany have included fuels purchased in other countries and brought into the country as "grey" imports.

At present, no precise data are available on this phenomenon, which is significant for truck and automobile traffic in Germany's border regions and which is referred to as "refuelling tourism" ("Tanktourismus"). Although several detailed studies have been carried out, no reliable overall picture of the situation is available (cf. LENK et al., 2005).

The sources that have documented shifting of consumers' fuel purchases to other countries (along with the resulting negative impacts on neighbouring countries' own emissions inventories) have included a study published by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW, 2005). The relevant neighbouring countries profit, to a not-inconsiderable degree, from additional revenue from energy taxation of such fuels. Such revenue is likely to be significantly higher than the certificate costs for the pertinent CO₂ emissions would be.

3.2.10.2.3 Uncertainties and time-series consistency (1.A.3.b)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

3.2.10.2.4 Source-specific quality assurance / control and verification (1.A.3.b)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances.

In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet¹⁹.

The emission factors used were compared with those of other countries. A number of countries were selected for this purpose; the emission factors included in the comparison were those of the Netherlands, Denmark, Switzerland, France, the UK, Norway and the European Union. The ranges covered by the various relevant groups of emission factors varied from greenhouse gas to greenhouse gas. All of the emission factors used by Germany are either right in the middle of the ranges for their groups in this context (this is the case for the emission factor for CO₂) or in the lower middle parts of those ranges (this is the case for the emission factors for CH₄ and N₂O).

3.2.10.2.5 Source-specific recalculations (1.A.3.b)

The presented emissions data were calculated with TREMOD version 5.11 (IFEU, 2010). Changes with respect to the 2009 report year include harmonisation of activity data (fuel consumption figures), for the years 2007 through 2009, with the latest figures from the Energy Balances, with official mineral-oil data of the Federal Office of Economics and Export Control (BAFA) and with data of the Association of the German Petroleum Industry (MWV) (cf. Annex Table 291).

Table 43: Recalculated greenhouse-gas emissions for road transports

	Units	1990	1995	2000	2005	2007	2008
Submission 2011	[Gg CO ₂ equiv.]	152,237.78	167,177.73	173,052.61	152,953.88	146,232.37	145,953.58
Submission 2010		152,237.78	167,177.73	173,052.61	152,954.83	146,152.48	145,974.70
Absolute difference		0.00	0.00	0.00	-0.95	79.89	-21.12
Relative difference	[%]	0.00	0.00	0.00	0.00	0.05	-0.01

3.2.10.2.6 Source-specific planned improvements (1.A.3.b)

No improvements are planned at present.

¹⁹ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63> (last checked on 30 October 2009)

3.2.10.3 Transport – Railways (1.A.3.c)

3.2.10.3.1 Source category description (1.A.3.c)

CRF 1.A.3.c										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions		2009 – contribution to total emissions		Trend			
All Fuels	- / t	CO ₂	0.24 %		0.12 %		-60.9 %			
Gas	CO ₂	CH ₄	HFCH FC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CONS ULTA NTS	CS	--	--	--	CS				
EF uncertainties in %	±7	±34	--	--	--	-42.5 +75				
Distribution of uncertainties	N	N	--	--	--	L				
EF-determination method	T2	T2	--	--	--	T2				

The source category *Railways* is a key category for CO₂ emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-60.9 %), and thus an extremely low emissions level has been attained (in 2009, emissions amounted to 33 % of the contribution of the smallest key source identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key sources.

Germany's railway sector is undergoing a long-term modernisation process, aimed at making electricity the main energy source for rail transports. Use of electricity, instead of diesel fuel, to power locomotives has been continually increased, and electricity now provides 80 % of all railway traction power²⁰. Railways' power stations for generation of required traction current are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the following section.

In energy input for trains operating in Germany, diesel fuel is the only energy source that plays a significant role apart from electric power. Since 2004, biodiesel has also been used, as an additive. Reliable figures for that fuel have been available since 2009.

In historic vehicles – primarily, steam-powered locomotives operated for exhibition purposes – small quantities of solid fuels are also used. The official Energy Balances provide pertinent evaluable consumption data for lignite, for the period until 2002, and for hard coal, for the period until 2000. Since no other evaluable statistics are available, emissions from consumption of solid fuels cannot be calculated for later years.

²⁰ From *Energiewirtschaftliche Tagesfragen*, 54th year (Jahrgang; 2004), issue 3, p. 185

Use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may still be considered negligible.

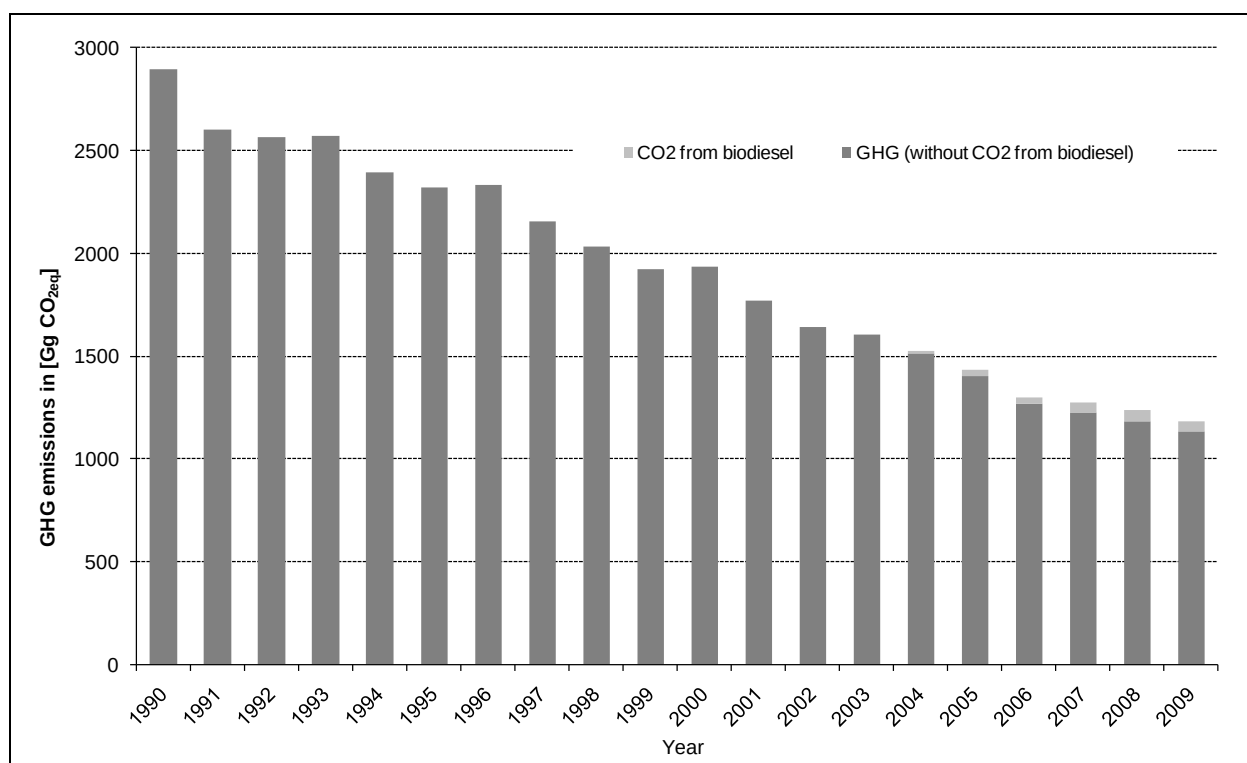


Figure 32: Development of greenhouse-gas emissions from railway transports, 1990-2009 (not including emissions from generation of electric power for railways)

3.2.10.3.2 Methodological issues (1.A.3.c)

No specific information relative to this source category is found in the IPCC Good Practice Guidance (2000: Chapter 2). The relevant emissions are thus calculated as the product of fuel consumption and the relevant country-specific emission factors. This procedure conforms to the general Tier 2 method and the basic calculation rule pursuant to equation 2.6 of the IPCC Good Practice Guidance (2000, p. 2.46).

Activity data:

As a rule, energy consumption data (currently, for the period from 1990 to 2008) are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2010). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 44: Sources for AD in 1.A.3.c

Fuel type	Energy Balance line	Relevant years
Diesel fuel	74	through 1994
	61	since 1995
Lignite briquettes	61	since 1996
Raw lignite	61	since 1996
Hard coal (Steinkohle)	74	through 1994
	61	since 1995
Hard-coal coke	61	since 1995

For those years for which no Energy Balance is yet available (currently: 2009), sales data of the Association of the German Petroleum Industry (MWV) are used as a basis. Those data

are published in the annual report "Petroleum Data" ("Mineralöl-Zahlen"; in the present instance: page 52, Table "Sectoral consumption of diesel fuel" ("Sektoraler Verbrauch von Dieselmotorkraftstoff") (MWV, 2010)).

As of the 2010 report, use of biogenic fuels (biodiesel) is also covered. Because the relevant data in the Energy Balances of 2004 and 2005 were incomplete, for the present report the annual consumption figures for those years were calculated on the basis of the official mixing quotas. As of the year 2006, the figures from the relevant Energy Balance lines are used.

In the present report, quantities of co-combusted lubricants, and the resulting CO₂ emissions, have been determined and reported for the first time (cf. the recalculations below). Due to a lack of pertinent figures on annual inputs of lubricants, i.e. figures such as those listed by the official mineral-oil statistics (Amtlichen Mineralölstatistik) for road transports and inland-waterway transports, the quantities of lubricants used are derived from the quantities of diesel fuel used. The co-combusted quantities of lubricants are then calculated on the basis of those lubricant figures.

Emission factors:

The emission factors are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- For CO₂, the reader's attention is called to the documentation in Annex 2, Chapter CO₂ emission factors. For co-combustion of lubricants, an IPCC default figure of 80,000 kg CO₂/TJ is currently being used.
- The CH₄ EF for solid fuels are based on the Federal Environment Agency study "Luftreinhaltung '88" ("Air Quality Control '88", UBA, 1989b). Those country-specific factors can be compared with the IPCC default values: for coal, the EF used are higher than those in the IPCC Reference Manual (1996b, Table 1-7). Specific emission factors, for diesel fuel and biodiesel, have been derived for all diesel locomotives in service in Germany. In emissions calculations, such locomotive-model-specific emission factors are linked with relevant operational mileage (kilometres travelled) for the relevant year (TREMOT; IFEU, 2010.) The default value in the IPCC Reference Manual (1996b, Table 1-7) is higher than the country-specific emission factors used by Germany, which take account, via a chronological progression, of engine-based measures to improve the emissions behaviour of railway vehicles (1995: 2.4 kg/TJ; 2009: 1.4 kg/TJ).
- As to the solid-fuel emission factor for N₂O, the Federal Environment Agency's experts agree with the Federal Environment Agency study "Luftreinhaltung '88" (UBA, 1989b). The country-specific EF are considerably higher than the corresponding values in the IPCC Reference Manual (1996b, Table 1-8). With regard to diesel fuel and biodiesel, a value is obtained by analogy to heavy duty vehicles without emissions-control equipment. The country-specific emission factor, at 1.0 kg/TJ, is higher than the value of 0.6 kg/TJ given by the Reference Manual (IPCC, 1997, Table 1-8).
- The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Table 45: Comparison of EF used and default EF

GG	EF used [kg/ TJ]	Default EF [kg/ TJ]
CH₄	Diesel & biodiesel 1.4 - 3.2	Oil 5.0 Coal 10.0
	Hard coal (Steinkohle) 15.0	
	Lignite briquettes 15.0	
	Raw lignite 15.0	
	Hard-coal coke 0.5	
N₂O	Diesel & biodiesel 1.0	Oil 0.6 Coal 1.4
	Hard coal (Steinkohle) 4.0	
	Lignite briquettes 3.5	
	Raw lignite 3.5	
	Hard-coal coke 4.0	

Source: Luftreinhaltung '88 (UBA, 1989b); IFEU (2009)

3.2.10.3.3 Uncertainties and time-series consistency (1.A.3.c)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

The activity-rate time series for lignite briquettes, hard coal and hard-coal coke exhibit inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present.

3.2.10.3.4 Source-specific quality assurance / control and verification (1.A.3.c)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet²¹.

The emission factors used were compared with those of other countries. A number of countries were selected for this purpose; the emission factors included in the comparison were those of the Netherlands, Denmark, Switzerland, France, the UK, Norway and the European Union. The ranges covered by the various relevant groups of emission factors varied from greenhouse gas to greenhouse gas. All of the emission factors used by Germany are either right in the middle of the ranges for their groups in this context (this is the case for the emission factor for CO₂) or in the lower middle parts of those ranges (this is the case for the emission factors for CH₄ and N₂O).

3.2.10.3.5 Source-specific recalculations (1.A.3.c)

Recalculations were carried out to take account of use of updated Energy Balance figures for consumption of diesel fuel (2008) and biodiesel fuel (as of 2006: transition from calculated values to Energy Balance values).

²¹ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63> (last checked on 30 October 2009)

The following table provides an overview of the recalculated activity data.

Table 46: Recalculated activity data (1.A.3.c)

Fuel	Reported in	Units	2006	2007	2008
Diesel	Resubmission 2010	[TJ]	17,014.00	16,436.00	15,444.39
	Submission 2011	[TJ]	17,014.00	16,436.00	15,932.00
Biodiesel	Resubmission 2010	[TJ]	495.60	733.32	763.23
	Submission 2011	[TJ]	494.00	733.00	784.00

In addition, the EF(CH₄) used for diesel and biodiesel, for emissions reporting, were harmonised with the values listed in TREMOD, Version 5.03; this led to recalculations of methane emissions from railway transports.

The following table presents a selective comparison of relevant emission factors from last year's report and from the current report.

Table 47: Comparison of the EF(CH₄) used last year and this year (1.A.3.c)

Reported in	Units	1995	2000	2005	2006	2007	2008
Resubmission 2010	[kg/TJ]	2.40	2.20	1.60	1.60	1.60	1.50
Submission 2011	[kg/TJ]	2.45	2.22	1.59	1.57	1.50	1.49

In addition, in the present report, CO₂ emissions from co-combustion of lubricants have been recorded and reported for the first time. The following table provides an overview of the calculated co-combusted quantities and the resulting CO₂ emissions.

Table 48: Trends for lubricants co-combusted in category 1.A.3.c, and the resulting CO₂ emissions (now being reported for the first time) as of 1990

Co-combusted lubricants (1.A.3.c)	Units	1990	1995	2000	2005	2006	2007	2008	2009
Energy input	[TJ]	19.23	15.53	12.71	9.64	8.75	8.58	8.36	7.97
CO ₂ emissions	[Gg]	1.54	1.24	1.02	0.77	0.70	0.69	0.67	0.64

The effects on the reported greenhouse-gas emissions for the source category are shown in the following tables.

Table 49: Effects of recalculations on total greenhouse-gas emissions in the source category, since 1990, except for CO₂ emissions from biodiesel (1.A.3.c)

Reported in	Units	1990	1995	2000	2005	2006	2007	2008
Resubmission 2010	[Gg CO ₂ -equiv.]	2,894	2,321	1,937	1,404	1,266	1,223	1,150
Submission 2011		2,896	2,322	1,938	1,405	1,267	1,224	1,186
Absolute difference		2	1	1	1	1	0	37
Relative difference	[%]	0.05	0.06	0.05	0.05	0.06	0.04	3.20

Table 50: Effects of recalculations on CO₂ emissions from Biodiesel, 2006 (1.A.3.c)

Reported in	Units	2004	2005	2006	2007	2008
Resubmission 2010	[Gg]	12.42	29.23	35.09	51.92	54.04
Submission 2011		12.42	29.23	34.98	51.90	55.51
Absolute difference		0.00	0.00	-0.11	-0.02	1.47
Relative difference	[%]	0.00	0.00	-0.31	-0.04	2.72

3.2.10.3.6 Source-specific planned improvements (1.A.3.c)

No improvements are planned at present.

3.2.10.4 Transport – Navigation (1.A.3.d)

3.2.10.4.1 Source category description (1.A.3.d)

CRF 1.A.3.d					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
	- / -				

Gas	CO ₂	CH ₄	HFCH FC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	--	--	--	CS				
EF uncertainties in %	±7	±34	--	--	--	-42.5 +75				
Distribution of uncertainties	N	N	--	--	--	L				
EF-determination method	T1	T1	--	--	--	T1				

The source category *Navigation* is not a key category.

Navigation is broken down into the categories "coastal and inland navigation" (domestic) and "international maritime transport". All domestic navigation is diesel-powered (and uses diesel fuel with added biodiesel), while heavy fuel oil (heavy oil) is also used in the international shipping sector. Emissions from international navigation are listed in the emissions inventories, as a memo item, but they are not included in total emissions.

Under source category 1.A.3d Navigation, the CSE includes coastal and inland fishing and coastal and inland shipping.

The following figure shows the development of greenhouse-gas emissions in inland shipping since 1990, which development parallels that for fuel inputs in this source category.

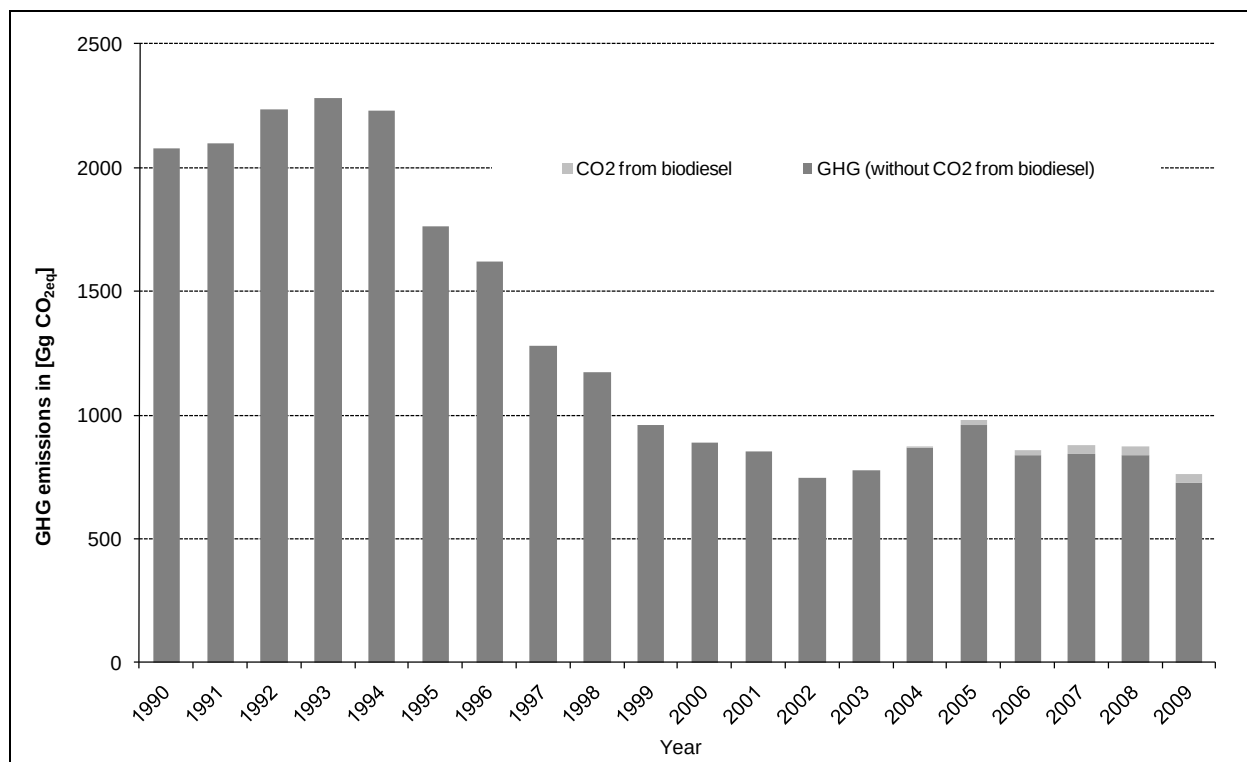


Figure 33: Development of greenhouse-gas emissions in inland shipping, 1990 – 2009

3.2.10.4.2 Methodological issues (1.A.3.d)

For Germany, emissions from this source category are calculated as the product of consumed fuels and country-specific emission factors for CO₂, CH₄ and N₂O. This procedure is in keeping with the general Tier 1 method and the basic calculation rule using the equation "emission factor times fuel consumption" pursuant to the IPCC Good Practice Guidance (2000: Chapter 2.4.1.1, p. 2.51). Refuelling in other countries is also a significant factor in the navigation sector, although no data are available on the relevant volumes involved (cf. Chapter 3.2.10.2.2).

Activity data:

In general, energy-consumption figures are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2010). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 51: Sources for AD in 1.A.3.d

Fuel type	Energy Balance line	
Diesel fuel	until 1994: 77 since 1995: 64	Coastal and inland navigation

For years for which no final Energy Balance is yet available, data of the Federal Office of Economics and Export Control (BAFA) are used as a basis. Those data are published as "Amtliche Mineralöl-daten für die Bundesrepublik Deutschland" ("Official mineral-oil data for the Federal Republic of Germany"; for the present context: Table 7j): "Inlandsablieferungen nach ausgewählten Verwendungssektoren" ("Domestic deliveries, by selected sectors") (BAFA, 2010).

Both official balances divide activity data in shipping into the categories *domestic* (AGEB: "Coastal and inland navigation" = BAFA: "an die Binnenschifffahrt" ("for inland shipping")) and *international* (AGEB: "high-seas bunkering" = BAFA: "Bunker int. Schifffahrt" ("bunkering for international shipping")), in accordance with the various differently taxed quantities of ship fuel sold. The manner in which emissions for domestic ship transports and international ship transports are separately calculated and listed (cf. Chapter 3.2.2.3) is in accordance with that breakdown. The criteria for breakdown of domestic and international emissions that are presented in the IPCC-GPG (2000: Table 2.8), on the other hand, cannot be used due to a lack of suitable movement data.

Fuel consumption in coastal and inland-waterway navigation varies in keeping with waterway navigability. Since the mid-1990s, the overall trend for such consumption has been a decreasing one, as many ships have been refuelling abroad in order to take advantage of lower fuel prices. The abrupt decrease that occurred in 1994/1995 was due solely to a conversion in the Energy Balance, however.

As of the 2010 report, use of biogenic fuels (biodiesel) is also covered. Because the relevant data in the Energy Balances for 2004 and 2005 were incomplete, for the present report the annual consumption figures for those years were calculated on the basis of the official mixing quotas.

In the present report, quantities of co-combusted lubricants, and the resulting CO₂ emissions, have been determined and reported for the first time (cf. the recalculations below). The relevant basis consists of figures from the official mineral-oil statistics (Amtliche Mineralöl-daten), of the Federal Office of Economics and Export Control (BAFA), relative to

annual domestic deliveries of lubricants to inland shippers; the pertinent co-combusted figures are derived from those figures.

For the years as of 2007, reliable official consumption figures for diesel - and, thus, for added biodiesel - are lacking. The reason for this is that the manner in which one, important, refinery operator reports to the Association of the German Petroleum Industry (MWV) differs from the reporting practices of other operators; this leads to erroneous figures in the official mineral-oil statistics. Therefore, the applicable quantities of burnt fuel and co-combusted lubricants were extrapolated from the corresponding consumption data of past years, on the basis of the applicable mileage travelled. As soon as the described statistical problems have been eliminated, this section will present suitable corrections.

Data on use of diesel fuel and heavy fuel oil in international maritime transports are provided in the Chapter International maritime transports (1.C.1.b).

Emission factors:

The diesel emission factors (which currently are adapted for biodiesel) for domestic navigation are based, for each specific gas in question, on the results of various research projects and experts' reviews conducted by the Federal Environment Agency:

- With regard to the CO₂ emission factor of 74,000 kg/TJ, the reader's attention is called to the documentation in Annex 2, Chapter "CO₂ emission factors". For co-combustion of lubricants, an IPCC default figure of 80,000 kg CO₂/TJ is currently being used.
- The CH₄ emission factors used have been derived from the value used for heavy duty vehicles without emissions control systems. A 15% reduction of specific CH₄ emissions in the period 1990 to 2005, resulting from engine improvements, has been assumed, in keeping with experts' estimates. The country-specific EF, at 2.4 to 2.8 kg/TJ, are also lower than the IPCC default value for diesel fuel, 5.0 kg/TJ, as listed in the Reference Manual (IPCC et al, 1996b, p. 1.35, Table 1-7).
- The emission factors for N₂O, are in keeping with Federal Environment Agency (UBA) experts' assessments based on the UBA study "Air Quality Control '88" ("Luftreinhaltung '88") and on analogies to heavy duty vehicles without emissions-control equipment. The country-specific EF for diesel fuel and biodiesel, at 1.0 kg/TJ, is higher than the value of 0.6 kg N₂O/TJ given by the Reference Manual (IPCC, 1996b: Table 1-8).

The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Data on use of diesel fuel and heavy fuel oil in international maritime transports are provided in Chapter 3.2.2.3 International maritime transports (1.C.1.b).

3.2.10.4.3 Uncertainties and time-series consistency (1.A.3.d)

In 2009, the uncertainties of the relevant activity data, emission factors and emissions were studied for the first time, in the framework of a research project (IFEU & INFRAS 2009).

The emission factors for CO₂ and N₂O are constant throughout the entire time series and, thus, are consistent.

The activity-data time series for coastal and inland shipping exhibit inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present.

3.2.10.4.4 Source-specific quality assurance / control and verification (1.A.3.d)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet²².

The emission factors used were compared with those of other countries. A number of countries were selected for this purpose; the emission factors included in the comparison were those of the Netherlands, Denmark, Switzerland, France, the UK, Norway and the European Union. The ranges covered by the various relevant groups of emission factors varied from greenhouse gas to greenhouse gas. All of the emission factors used by Germany are either right in the middle of the ranges for their groups in this context (this is the case for the emission factor for CO₂) or in the lower middle parts of those ranges (this is the case for the emission factors for CH₄ and N₂O).

3.2.10.4.5 Source-specific recalculations (1.A.3.d)

With respect to the data provided in the Resubmission 2010, recalculations were carried out to take account of first-time inclusion of co-combusted lubricants and the resulting CO₂ emissions. The following table provides an overview of the calculated co-combusted quantities and the resulting CO₂ emissions.

Table 52: Trends for lubricants co-combusted in category 1.A.3.d, and the resulting CO₂ emissions (now being reported for the first time) as of 1990

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Energy input	[TJ]	198.64	149.64	70.48	39.40	36.36	34.30	35.54	26.12
CO ₂ emissions	[Gg]	15.89	11.97	5.64	3.15	2.91	2.74	2.84	2.09

In addition, the EF(CH₄) used for diesel and biodiesel, for emissions reporting, were harmonised with the values listed in TREMOD, Version 5.11; this led to recalculations of methane emissions from inland shipping as of 1995.

The following table presents a selective comparison of relevant emission factors from last year's report and from the current report.

²² AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63> (last checked on 30 October 2009)

Table 53: Comparison of the EF(CH₄) used last year and this year

Reported in	Units	1995	2000	2005	2006	2007	2008
Resubmission 2010	[kg/TJ]	2.70	2.50	2.40	2.40	2.40	2.40
Submission 2011	[kg/TJ]	2.65	2.51	2.37	2.37	2.37	2.37

In addition, a minimal correction was required, for 2006 only, in the activity data for biodiesel, as a result of the transition from calculated values to Energy Balance values (cf. the activity data above).

Table 54: Changes as a result of the transition from calculated values to Energy Balance values

Reported in	Units	2006
Resubmission 2010	TJ	325.90
Submission 2011		325.00

The effects on the reported greenhouse-gas emissions for the source category are shown in the following tables.

Table 55: Effects of recalculations on total greenhouse-gas emissions in the source category, since 1990, except for CO₂ emissions from biodiesel

Reported in	Units	1990	1995	2000	2005	2006	2007	2008
Resubmission 2010	[Gg CO ₂ -equiv.]	2,060.04	1,752.23	882.24	954.22	832.06	841.75	833.18
Submission 2011		2,075.93	1,764.18	887.88	957.36	834.96	844.49	836.02
Absolute difference		15.89	11.95	5.64	3.14	2.90	2.74	2.84
Relative difference	[%]	0.77	0.68	0.64	0.33	0.35	0.33	0.34

Table 56: Effects of recalculations on CO₂ emissions from biodiesel. 2006

Reported in	Units	1990	1995	2000	2005	2006	2007	2008
Resubmission 2010	[Gg]	0.00	0.00	0.00	19.87	23.07	35.77	39.19
Submission 2011		0.00	0.00	0.00	19.87	23.01	35.77	39.19
Absolute difference		0.00	0.00	0.00	0.00	-0.06	0.00	0.00
Relative difference	[%]	0.00	0.00	0.00	0.00	-0.28	0.00	0.00

Recalculations on the basis of the in-country review 2010 are presented in Chapter 10.5.2.3.

3.2.10.4.6 Source-specific planned improvements (1.A.3.d)

Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.3.d.

3.2.10.5 Transport – Other transport (1.A.3.e)

3.2.10.5.1 Source category description (1.A.3.e)

CRF 1.A.3.e					
Key source nach Level 8l) / Trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	I / - / T2	CO ₂	0.35 %	0.38 %	-16.2 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	--	--	--	CS	--	--	--	--
EF uncertainties in %	±3	±34	--	--	--	-42.5 +75				
Distribution of uncertainties	N	N	--	--	--	L				
EF-determination method	T1	T1	--	--	--	T1				

The source category *Other transport* is a key source of CO₂ emissions in terms of level.

Reporting in source category 1.A.3.e – Other transport includes emissions from construction-related transports and from gas turbines in natural-gas compressor stations. Construction-related transports are included in the Energy Balance category "Commercial and institutional and other consumers". Gas turbines in natural-gas compressor stations, on the other hand, are a clearly defined plant type.

3.2.10.5.2 Methodological issues (1.A.3.e)

The emissions for the aforementioned areas are calculated as the product of fuel consumption and the relevant country-specific emission factors. The IPCC Good Practice Guidance (2000) provides no specific provisions for "good practice" in connection with Other transport. The selected procedure is in keeping with the general Tier 1 method as set forth, for example, in equation 2.3 of the IPCC Good Practice Guidance (2000: p. 2.37).

Activity data:

The area **construction-sector transports** accounts for the majority of energy inputs in this source category. The diesel and petrol consumption data are taken from Energy Balance lines 79 and 67 (through 1994 and as of 1995) (cf. Chapter 18.2), following deduction of energy inputs for military and agricultural transports. Since construction transports are significant to this category's status as a key source, the calculation procedure used for this category should be as detailed as possible. At present, due to a lack of detailed data, only the above-described Tier 1 method can be used, however.

The area of **natural gas compressor stations** accounts for the smaller share of energy inputs. The activity data used for the years 1995 until 2002 have been taken from the Energy Balances of the Federal Republic of Germany. Natural-gas-consumption data have been provided in a revised form since the 2007 report. The relevant values, along with those for natural gas inputs in coking plants and local gas works, are listed in the Energy Balance in the line "Transformation inputs of coking plants" (EB line 33). The relevant input figures for coking plants and natural gas compressor stations were provided to the Federal Environment Agency via a special evaluation of the Working Group on Energy Balances (AGEB). For the years 1998 to 2002, natural gas inputs of natural gas compressor stations are listed as such in the Energy Balance, EB line 33. Since this area is an insignificant sub-emissions area of the source category in question, the above-described Tier 1 method was used.

For the years 1990 to 1994, natural gas inputs in compressors were determined via the factor 0.005, which is linked with domestic natural gas consumption. The same method was used for the period as of 2003. The factor 0.005 has been obtained as the average of the ratios between a) the statistically documented input quantities in natural gas compressor stations for the years 1995 to 2002 and b) the relevant primary energy consumption figures.

Emission factors:

The emission factors for emissions of **construction-sector transports** are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- For CO₂, the reader's attention is called to the documentation in Annex 2, Chapter CO₂ emission factors.
- The country-specific CH₄ emission factors have been updated. As of this report year, they are based on a Federal Environment Agency study of the emissions of mobile machinery (IFEU, 2009). These factors reflect the emissions standards that have been phased in gradually, since the mid-1990s, for construction-sector machinery. For 2009, the relevant value for diesel fuel is 1.6 kg/TJ (1995: 4.1 kg/TJ), while for petrol it is 20.6 kg/TJ (1995: 22.8 kg/TJ).
- The country-specific N₂O emission factors for petrol (for the old German Länder for 1990-1994, and for all of Germany as 1995: 3.7 kg/TJ; for the new German Länder for 1990-1994: 2.1 kg/TJ) were also obtained from the Federal Environment Agency study "Air Quality Control '88" ("Luftreinhaltung '88" (UBA, 1989b)). The N₂O emission factor for diesel fuel, 1.0 kg/TJ, was derived, by analogy, from the value for heavy duty vehicles without emissions-control equipment.

The emission factors for natural-gas use in **natural gas compressor stations** are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- For CO₂, the reader's attention is called to the documentation in Annex 2, Chapter CO₂ emission factors.
- The CH₄ and N₂O EF have been taken from Chapter 4.9.5 and Annex E, Table 5 of the Federal Environment Agency study on stationary combustion systems (RENTZ et al, 2002); the procedure used in the study is described in Chapter 3.2.6.2.

3.2.10.5.3 Uncertainties and time-series consistency (1.A.3.e)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion plants", of the NIR 2007.

The EF time series for N₂O for petrol (construction industry) exhibits inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present. Since 1995, relevant activities in the new German Länder have not been listed separately. As a result, emissions cannot be calculated using new-Länder EF that diverge from those for the old German Länder. Since it cannot be assumed that specific emissions – and, thus, EF – were comparable in the old and new German Länder until 1994, the different EF for those years have been retained. As a result, the time series contains a methodological change, manifested as a jump in the overall EF (IEF).

The procedure for determining uncertainties for natural-gas-compressor stations is described in Chapter 3.2.6.2. Results for N₂O are presented in Chapter 3.2.6.3.2, while those for CH₄ are presented in Chapter 3.2.6.3.3 .

3.2.10.5.4 Source-specific quality assurance / control and verification (1.A.3.e)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet²³.

For purposes of further verification of calculated fuel inputs in natural gas compressor stations, plans call for data from emissions trading to be allocated to the relevant economic sectors and then compared with the pertinent data from emissions reporting. To rule out any possibility of double-counting, such comparisons will have to be carried out extremely carefully.

In addition, implied emission factors (IEF) for the area of construction-sector transports were compared with those of other countries. Due to this source category's highly heterogeneous composition, however, such comparisons are extremely difficult to carry out for methane and nitrous oxide.

Natural-gas-compressor stations: The results of Chapter 3.2.6.4 apply mutatis mutandis.

3.2.10.5.5 Source-specific recalculations (1.A.3.e)

Construction-sector transports:

Changes in the figures taken from the Energy Balances (Energy Balance line 67), along with changes in the emission factors for methane, made it necessary to recalculate emissions from construction-sector transports for all report years.

For the present report, the EF(CH₄) were brought into line with the values in TREMOD-MM (Mobile Machinery). For the years prior to 1995 in particular, those values deviate – considerably, in some cases – from the values previously used in the CSE. Data analysis is no longer being carried out separately for the new German Länder and the old German Länder for the years 1990 through 1994.

The following table presents a selective comparison of the time series for the EF(CH₄) previously reported and the EF(CH₄) currently being used.

²³ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63> (last checked on 30 October 2009)

Table 57: EF(CH₄) for construction-sector transports as of 1990, as brought into line with the revised TREMOD-MM model (in [kg/TJ])

Reported in	Material	Area of application	1990	1994	1995	2000	2005	2006	2007	2008
Resubmission 2010	Diesel fuel	ABL	8.0	8.0						
		D			4.4	3.9	2.5	2.2	2.0	1.8
		NBL	6.0	6.0						
	Petrol	ABL	37.0	37.0						
		D			28.4	26.7	26.3	26.3	26.23	26.3
		NBL	140.0	140.0						
Submission 2011	Diesel fuel	D	4.86	4.23	4.1	3.6	2.4	2.1	1.9	1.7
	Petrol	D	24.9	23.2	22.8	21.1	20.6	20.6	20.6	20.6

In the following table, the methane emissions as recalculated on the basis of the changed emission factors are compared with the values reported last year.

Table 58: Comparison of construction-sector methane emissions, 1990-2008, as reported last year and as reported this year

Reported in	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Resubmission 2010	[Gg]	0.4	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Submission 2011		0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Absolute difference		-0.1	-0.2	-0.2	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0
Relative difference	[%]	-32.6	-36.9	-38.9	-40.6	-41.2	-10.6	-10.7	-10.7	-10.8	-11.1
Reported in	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Resubmission 2010	[Gg]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	-
Submission 2011		0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Absolute difference		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Relative difference	[%]	-11.4	-11.7	-11.8	-11.9	-12.4	-12.8	-13.8	-14.2	-12.5	-

The following table shows the effects of the aforementioned changes, in the database on which the calculations are based, on the inventory of construction-sector emissions, for the entire time series.

Table 59: Comparison of construction-sector greenhouse emissions, 1990-2008, as reported last year and as reported this year

Reported in	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Resubmission 2010	[Gg CO ₂ -equiv.]	3,692	3,761	3,204	3,293	3,272	3,287	3,227	3,245	3,208	3,288
Submission 2011		3,689	3,757	3,201	3,289	3,268	3,287	3,226	3,245	3,208	3,288
Absolute difference		-3.0	-3.7	-3.4	-3.6	-3.6	-0.6	-0.6	-0.6	-0.6	-0.6
Relative difference	[%]	-0.08	-0.10	-0.11	-0.11	-0.11	-0.02	-0.02	-0.02	-0.02	-0.02
Reported in	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Resubmission 2010	[Gg CO ₂ -equiv.]	3,199	3,086	3,036	2,997	2,910	2,780	2,826	2,803	2,836	-
Submission 2011		3,199	3,085	3,036	2,997	2,909	2,779	2,826	2,802	2,853	2,802
Absolute difference		-0.6	-0.5	-0.5	-0.5	-0.5	-0.4	-0.5	-0.4	16.7	-
Relative difference	[%]	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	0.59	-

Natural-gas-compressor stations: The results of Chapter 3.2.6.5 apply mutatis mutandis.

3.2.10.5.6 Source-specific planned improvements (1.A.3.e)

Natural-gas-compressor stations: The new research project described in Chapter 3.2.6.5, aimed at updating emission factors (except for those for CO₂), will also cover gas turbines in natural gas compressor stations.

In future, emissions from construction-sector transports will be reported under 1A.2.f ii. No additional improvements are planned at present.

3.2.11 Other: Residential, commercial/institutional, agriculture, forestry and fisheries (1.A.4)

3.2.11.1 Source category description (1.A.4)

CRF 1.A.4					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
CRF 1.A.4.a (Commerce, trade, services / commercial and institutional)					
All Fuels	l / t / T2	CO ₂	5.24 %	4.00 %	-41.2 %
All Fuels	- / t	CH ₄	0.10 %	0.01 %	-95.4 %
CRF 1.A.4.b (Residential)					
All Fuels	l / t / T2	CO ₂	10.60 %	10.91 %	+20.9 %
CRF 1.A.4.c (Agriculture, forestry and fisheries)					
All Fuels	l / t / T2	CO ₂	0.91 %	0.64 %	-45.3 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
<i>CRF 1.A.4.a (Commerce, trade, services / commercial and institutional)</i>										
EF uncertainties in %		-70	-	-	-	-70				
- liquid fuels		+100	-	-	-	+100				
EF uncertainties in %		-70	-	-	-	-40				
- gaseous fuels		+100	-	-	-	+60				
EF uncertainties in %		-70	-	-	-	-50				
- solid fuels		+100	-	-	-	+80				
<i>CRF 1.A.4.b Residential</i>										
EF uncertainties in %		-30	-	-	-	-30				
- liquid fuels		+50	-	-	-	+50				
EF uncertainties in %		-15	-	-	-	-45				
- gaseous fuels		+23	-	-	-	+70				
EF uncertainties in %		-60	-	-	-	-15-60				
- solid fuels		+90	-	-	-	+23-85				
<i>CRF 1.A.4.c Agriculture and forestry</i>										
EF uncertainties in %		-70	-	-	-	-70				
- liquid fuels		+100	-	-	-	+100				
EF uncertainties in %		-70	-	-	-	-40				
- gaseous fuels		+100	-	-	-	+60				
EF uncertainties in %		-70	-	-	-	-40-60				
- solid fuels		+100	-	-	-	+60-100				
Distribution of uncertainties		L	-	-	-	L				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

All of the uncertainties given in the table should be understood solely as guideline values. The uncertainties based on the emissions database have been determined separately for each fuel. The uncertainties as used in calculation of the inventory uncertainty are more highly detailed.

The source category 1.A.4 *Other* is a key source of CO₂ emissions, in terms of both emissions level and trend, in all of its sub - source categories. The sub- source category *Commercial and institutional* is also a key source of CH₄ emissions, in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-95.4 %), and thus an extremely low emissions level has been attained (in 2009, emissions amounted to 1.7 % of the contribution of the smallest key source identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key sources.

Source category 1.A.4 comprises combustion systems in the areas Residential, Commercial and institutional (commerce/trade/services) and Agriculture, along with various mobile sources.

Heat-generation systems in small combustion systems of small commercial and institutional users are reported in sub- source category 1.A.4.a. Commercial and institutional.

1.A.4.b comprises energy inputs in households (the Residential sector). This refers primarily to combustion systems. In addition, source category 1.A.4.b includes residential mobile sources (not including road transports).

Sub- source category 1.A.4.c comprises the areas of agriculture, forestry and fisheries. Reporting under this category includes emissions from heat generation in small and medium-sized combustion systems and emissions from agricultural transports. Pursuant to the IPCC structure, 1.A.4.c also includes emissions from mobile sources in fisheries and in forestry. The present report provides the first separate report on activities and emissions from German deep sea fishing. Previously, such activities and emissions were part of international maritime transports (cf. Chapter 3.2.2.3), which were considered for information purposes only, and thus were not part of the national inventory.

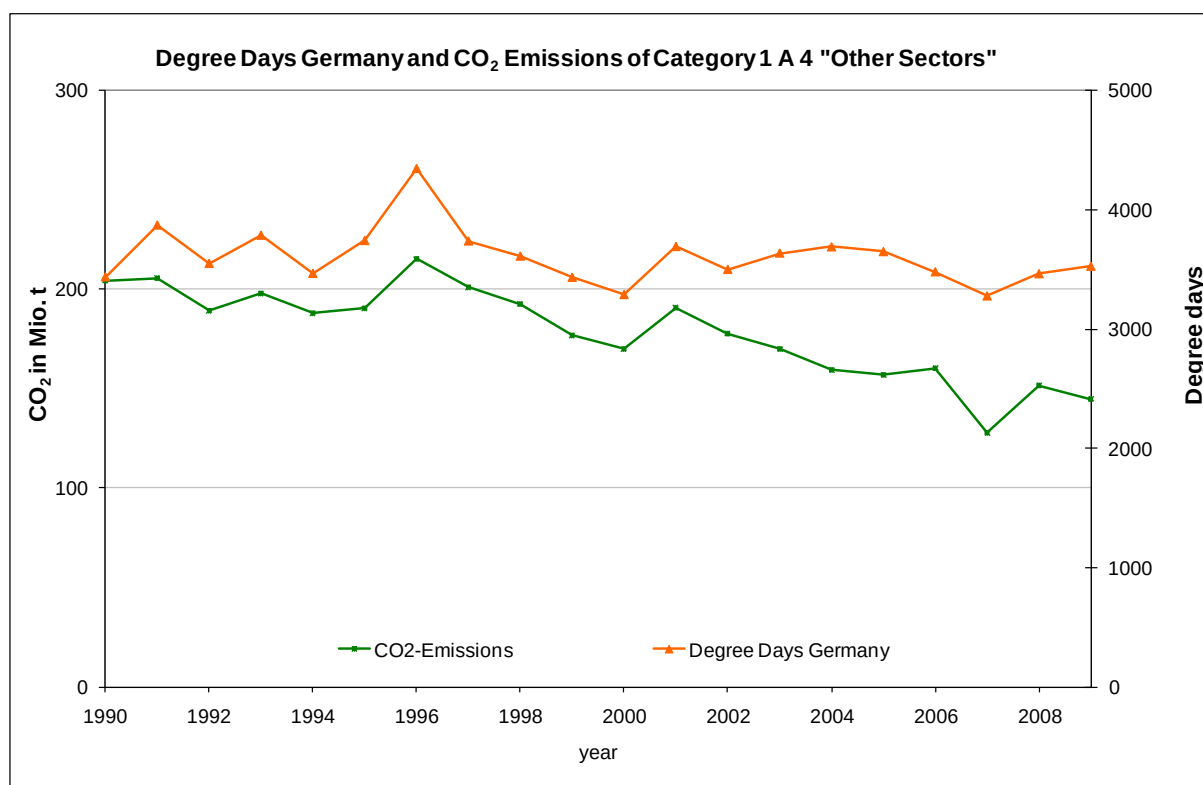


Figure 34: Change in total emissions of 1.A.4, as a function of temperature [y axis: left: CO₂ in millions of t; right: degree days; top: Degree days in Germany, and CO₂ emissions of 1.A.4 "Other"; CO₂ emissions; Degree days; x axis: year]

The main driver of CO₂ emissions in 1.A.4 is energy consumption for purposes of space heating. Consequently, fluctuations in consumption can plausibly be attributed to differences in periods of winter cold. The trend toward lower CO₂ emissions is a result of higher standards for new buildings and of successful execution of energy-efficiency-oriented modernisations of existing buildings. The trend has also been boosted by shifting to fuels with lower CO₂ emissions. On the other hand, CO₂ emissions from heat pumps, which are being used more and more frequently in new buildings, are not reported here.

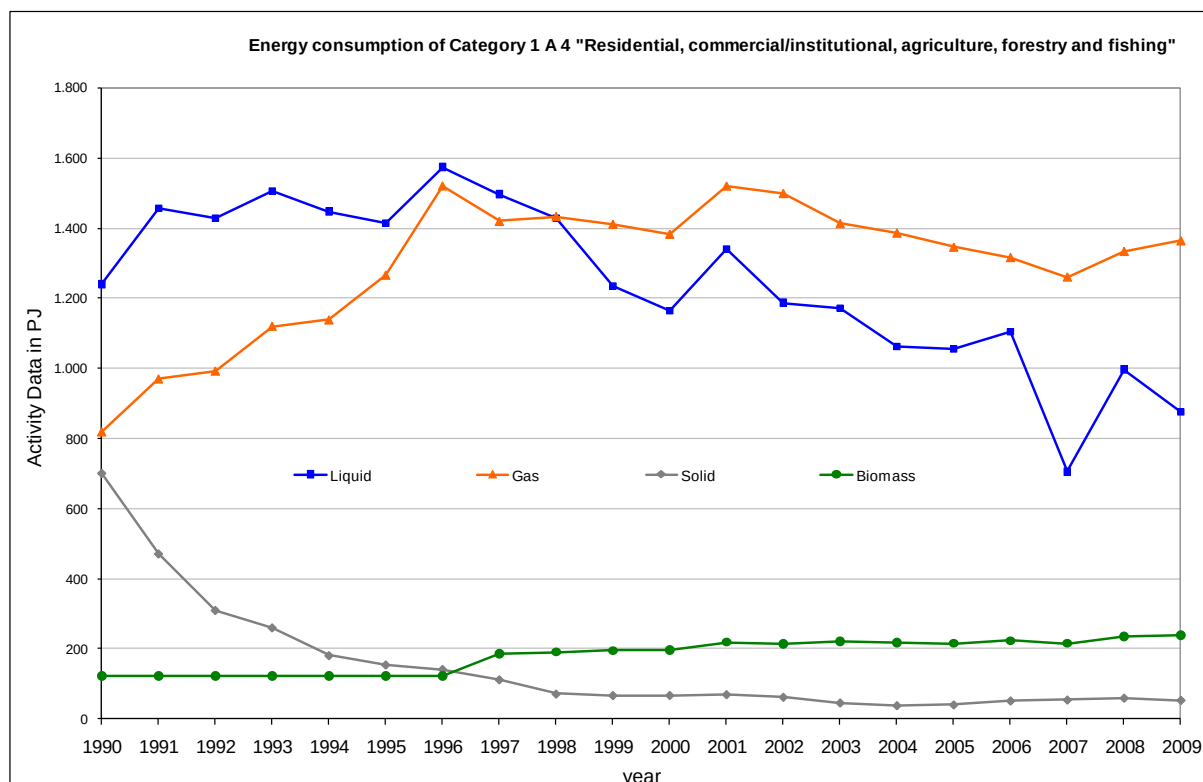


Figure 35: Trends in energy consumption in 1.A.4, for 4 fuel categories [y axis: Energy consumption in PJ; x axis: year; top: Development of energy consumption in source category 1.A.4; Liquid fuels; Gases; Solid fuels; Biomass]

Shifting from liquid fuels (almost exclusively heating oil) and solid fuels (mainly coal) to gaseous fuels (natural gas) and biomass has brought about considerable CO₂-emissions reductions. In 2006 and 2007, a special phenomenon occurred whereby energy consumption was first above-average and then below-average, as a result of an increase in the value-added-tax (VAT) rate from 16 % to 19 %. Very high heating-oil sales in 2006 brought about increasing CO₂ emissions, since emissions data relative to heating oil are determined on the basis of sales, rather than consumption.

The group of combustion systems in the Residential and Commercial/Institutional sectors is very diverse with regard to installation design and size. It covers a spectrum that includes individual room furnaces for solid fuels with a rated thermal output of approximately 4 kW (e.g. fireplaces, ovens), oil and gas furnaces used to generate room heat and hot water (e.g. central heating boilers), hand-fed and automatically fed wood-burning furnaces in the commercial sector and commercial/institutional users' licensable combustion systems with a rated thermal output of several megawatts, to name but a few examples. In total in 2005, more than 36.5 million combustion systems were installed in Germany in the Residential and Commercial/Institutional sectors (STRUSCHKA, 2008: p. 12). Gas-fired combustion systems accounted for a majority of these systems, or some 14.5 million, while combustion systems using solid fuels accounted for some 14.4 million systems and oil-fired furnaces accounted for some 7.9 million systems. The great majority of these systems (about 95 %) are in place in private households (STRUSCHKA, 2008).

Of the wood fuels used in households and in commerce and trade, large quantities are purchased privately or obtained from system owners' own forest parcels. For this reason, in the Energy Balance, the relevant data from the Federal Statistical Office are supplemented with data from a survey of firewood consumption in private households. Data relative to use

of firewood in the source categories commercial and institutional are based on a study from the year 2000 (UBA 2000a). The consumption-level figures determined in that study have been adopted for subsequent years since then. A research project entitled "determination of consumption of biogenic solid fuels in the commercial and institutional sector" ("Ermittlung des Verbrauchs biogener Festbrennstoffe im GHD-Sektor") is currently underway with the aim of facilitating more precise future determination of wood-fuel activity data in the commercial and institutional sector. The Energy Balance fuel category "Waste and other biomass" is specified in greater detail in the Satellite Balance. The information in that Balance indicates that only firewood is used in the residential sector, while only gas from wastewater treatment / biogas are used in the sector "Commercial, institutional (commerce/trade/services) and other consumers".

3.2.11.2 Methodological issues (1.A.4)

Activity data

The activity data in source category 1.A.4 are based on the Energy Balances for the Federal Republic of Germany, as prepared by the Working Group on Energy Balances (AGEB). For years prior to 1995 separate Energy Balances are used for the a) old German Länder and b) new German Länder. For years as of 1995, lines 66 (residential) and 67 (commercial and institutional and other consumers) are the standard.

The quantities of gasoline fuels listed in line 66 are all allocated to mobile sources in the residential sector (sub-category *1.A.4.b (ii)*).

Since the data in Energy Balance line 67 – commercial and institutional and other consumers – also include military consumption (offices, and vehicles and aircraft), such military consumption must be deducted from the relevant positions in line 67 (cf. Chapter 3.2.12 with regard to stationary and mobile sources in the military sector).

For energy inputs in *agricultural combustion systems (1.A.4.c (i))*, which are also included in line 67 of the Energy Balance, relevant data are available in an existing study (UBA, 2000a) for 1995. That study provides an estimate of agricultural combustion systems' share of total energy inputs in line 67. That share is assumed to have remained constant since then.

Consumed quantities of diesel fuel and gasoline, which are also included in line 67, are allocated completely to mobile consumers (construction-sector, agricultural and military transports). The relevant share for *agricultural transports (sub-category 1.A.4.c (ii))* is obtained by deducting pertinent military consumption, as obtained from BAFA data (cf. Chapter 3.2.12), and by deducting construction-sector transports (cf. Chapter 3.2.10.5).

The activity data for deep sea fishing, which are now recorded under *1.A.4.c (iii) – Fisheries*, are conservatively calculated on the basis of the engine types/performance used on active German fishing vessels (EC, 2010) and a fixed consumption level of 200g diesel fuel per kWh.

Emission factors

The basic data for the emission factors used for N₂O und CH₄, for stationary combustion systems, is provided by the research report "Efficient provision of current emissions data for purposes of air quality control" ("Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung"; STRUSCHKA 2008). Within the context of that project, device-related and source-category-specific emission factors for combustion systems in the residential and

commercial/institutional sectors were calculated, with a high level of detail, for all important emissions components for the reference year 2005.

Determination of emission factors is based on a source-category-specific "bottom-up" approach that, in addition, to differentiating (sub-) source categories and fuels, also differentiates system technologies in detail. In the process, several system-specific emission factors are aggregated in order to obtain mean emission factors for all systems within the source categories in question. Use of system-specific / category-specific emission factors ensures that all significant combustion-related characteristics of typical systems for the various categories are taken into account. The procedure is in keeping with the Tier 2/3 method described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006).

The emission factors are structured in accordance with the relevant fuels involved in final energy consumption in Germany:

- Fuel oil EL,
- Natural gas,
- Lignite (briquettes from the Rhine (Rheinisch) and Lusatian (Lausitz) coal fields; imported briquettes),
- Hard coal (coke, briquettes, anthracite) and
- Wood (unprocessed wood, wood pellets, residual wood).

In addition, emission factors for combustion systems are determined in accordance with device design, age level, output category and typical mode of operation. The emissions behaviour of the combustion systems in question was determined via a comprehensive review of the literature, in an approach that distinguished between results from test-bench studies and field measurements. Transfer factors were used to take account of the fact that emissions in a test-bench environment tend to be lower than those of corresponding installed systems.

The description of the structure for installed combustion systems was prepared using statistics from the chimney-sweeping trade, as well as with the help of surveys conducted by the researchers themselves in selected chimney-sweep districts of Baden-Wuerttemberg, North-Rhine Westphalia and Saxony. Those data were used to estimate the energy inputs for various system types, to make it possible to determine sectoral emission factors weighted by energy inputs. Table 60 shows the sectoral emission factors determined.

Table 60: Sectoral emission factors for combustion systems in the residential and commercial/institutional sectors for reference year 2005

1.A.4.b (i) - Residential	CH₄	N₂O
	[kg/ TJ]	
Hard coal	129	11
Briquettes	368	9.7
Hard-coal coke	13	0.82
Lignite briquettes	55	5.2
Unprocessed wood	100	1.5
Heating oil EL	0.046	0.55
Natural gas	2.3	0.25
1.A.4.a (i) & c(i)- Commerce, trade and services (commercial/institutional)		
Hard coal	100	10
Briquettes	-	-
Hard-coal coke	-	-
Lignite briquettes	-	-
Wood fuels	56	1,1
Heating oil EL	0.026	0.56
Natural gas	0.16	0.33

The emission factors for 2005 were used, without change, for subsequent years.

Table 61: Sectoral emission factors for mobile sources of the residential, agricultural-transports and fisheries sectors

1.A.4.b (ii) - Mobile sources of the residential sector	CH₄	N₂O
	[kg/ TJ]	
Petrol	37.0	3.7
1.A.4.c (ii) – Agricultural transports		
Diesel fuel	5.0	1.0
Petrol	37.0	3.7
1.A.4.c (iii) – Fisheries (here: deep sea fishing)		
Diesel fuel	7.0	2.0

3.2.11.3 Uncertainties and time-series consistency (1.A.4)

A complex procedure is required to calculate reliable emission factors in this installation sector. Apart from emission figures, it is also necessary to obtain other information; for example, one must make allowance for the relevant mode of operation (loads), installation structure and device-specific final energy consumption. In data surveys during the aforementioned research and development project, this approach was for the most part followed; nevertheless, given the sheer number of facilities concerned and the wide range of combustion systems and fuels used, the data must be assumed to have a fairly large "basic uncertainty".

For some installation types, moreover, only inadequate data or no data at all were available on emissions behaviour in connection with certain fuels. It is important to remember that the law does not require the greenhouse-gas emissions of combustion systems of residential and commercial/institutional users to be measured. When calculating the emission factors, therefore, in most cases (with the exception of CO₂, which is largely independent from furnace design) the researchers only had recourse to a few results from individual

measurements on selected installations. Gaps in the data were closed via adoption of emission factors of comparable combustion systems.

The uncertainties listed for the emission factors for CH₄ and N₂O, for stationary combustion systems, were determined via experts' assessment pursuant to IPCC-GPG (2000: Chapter 6). That assessment, which is based on the emissions data obtained for the aforementioned research project, was carried out in the framework of that project by experts of the University of Stuttgart's Institute of Process Engineering and Power Facility Technology (Institut für Verfahrenstechnik und Dampfkesselwesen). Uncertainties were estimated separately for all combustion technologies and fuels. The following sources of error entered into the estimate for N₂O and CH₄:

- Measuring errors in determination of pollutant concentrations;
- Uncertainties in estimating transfer factors (systematic differences between test-bench and field measurements);
- Uncertainties resulting from having too little emissions data;
- Uncertainties resulting from use of different measuring procedures;
- Uncertainties in the installation data used (overall group structure in terms of type, age and performance and fuel consumption)

In gas-fired systems, another error occurs in determination of start-up/shutdown emissions. During start-up/shutdown procedures, some partly unburned CH₄ is emitted from natural gas. Those emissions, which occur upstream and downstream from the actual combustion process, cf. Chapter 3.3.2.4 (natural gas), are a significant reason why CH₄ emission factors for gas-combustion systems are subject to high levels of uncertainties.

As to the distribution of uncertainties, a log-normal distribution is assumed for N₂O emission factors. In all likelihood, the deviations are considerably more pronounced in the vicinity of larger values than they are in the vicinity of smaller values. The emission factors for CH₄ and N₂O were determined for the year 2005, in the framework of the aforementioned research project, and are assumed to have remained constant since then.

Annex 2, Chapter 13.6 in the NIR 2007 describes the method used to determine the uncertainties for the **activity data**.

To date, default uncertainties pursuant to IPCC have been used for *mobile residential sources* and *agricultural transports*.

3.2.11.4 Source-specific quality assurance / control and verification (1.A.4)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet²⁴.

For the purposes of quality assurance for data relative to *stationary combustion systems*, in the context of the aforementioned research and development project, all the input data used

²⁴ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63> (last checked on 15 October 2010)

from literature and from the research company's own investigations were reviewed for validity. As a general principle, in description of the emissions behaviour of combustion systems, emissions data were included in subsequent calculations only if the relevant literature sources contained complete, undisputed data on the fuel used, the design of the furnace, and the furnace's operating mode during measurements. All resources of significance for inventory preparation were substantiated by the research company.

In the framework of a quality review carried out by Federal Environment Agency experts, the country-specific emission factors for CH₄ and N₂O, determined in accordance with the Tier 2 standard, were compared with the IPCC Tier 2 default factors in the IPCC Guidelines for emissions inventories (IPCC 2006). For most fuels, the values agreed well (discrepancies within one order of magnitude), although the default values for CH₄ tended to be higher than the country-specific values.

In the framework of quality assurance, calculation with the Tier 1 default values was carried out, in addition to emissions determination pursuant to Tier 2/3, for the residential and commercial/institutional sectors for the year 2005. The results are shown in Table 62.

Table 62: Emissionsberechnung mit landesspezifischen Tier 2/3 Emissionsfaktoren und mit den Tier 1 Default-Emissionsfaktoren nach (IPCC 2006)

Emission factors	CH ₄ [t]				N ₂ O [t]			
	Residential		Commercial and institutional		Residential		Commercial and institutional	
	Tier 1 default	Struschka 2008	Tier 1 default	Struschka 2008	Tier 1 default	Struschka 2008	Tier 1 default	Struschka 2008
Heating oil EL	6,590	30	2,489	6.5	395	357	149	139
Fuel gases	5,290	2,459	2,496	77	106	266	50	163
Coal fuels	13,452	4,568	6	58	67	340	1	5.6
Wood	60,194	20,001	5,749	1,081	803	284	77	6.2
Total	85,526	27,058	10,740	1,223	1,371	1,247	279	313.8

The emissions for the commercial/institutional ("small consumers") sector include the emissions of the areas of agriculture, forestry and fisheries.

For N₂O, the emissions-calculation results obtained with both methods showed good agreement. Larger discrepancies were seen in determination of CH₄ emissions. Presumably, this is due to the fact that methane emissions of combustion systems depend strongly on the combustion technology used. Differences in installation structures (i.e. in sector composition), from country to country, thus manifest themselves much more strongly in total emissions (as determined) than in nitrous-oxide emissions. The default emission factor for heating oil, in particular, is very high. The technology-specific emission factor given in IPCC 2006 for boilers shows considerably better agreement with the pertinent country-specific factor for Germany.

3.2.11.5 Source-specific recalculations (1.A.4)

As a result of corrections made in the provisional Energy Balance 2008, a few slight changes in the activity data for 2008 had to be made. In the natural gas category, a significant increase occurred, amounting to 3.5 million t CO₂ (1.A.4.a with 2.7 million t CO₂ and 1.A.4.b with 0.8 million t CO₂).

The CH₄ and N₂O emission factors for *stationary combustion systems* were recalculated last year. Those emission factors were then adopted, without change, for the 2009 report.

For *mobile sources*, no recalculations were carried out with respect to the Resubmission 2010.

The changes made in the Resubmission 2010, with respect to the Submission 2010 (first-time inclusion of national deep sea fishing) are described in detail in Chapter 10.5.2.4.

3.2.11.6 Source-specific planned improvements (1.A.4)

At present, no improvements are planned with respect to reporting on *stationary combustion systems*.

The current survey of consumption and emissions of German deep sea fishing, which is based on a number of highly simplified and conservative assumptions, is to be revised in the medium term.

3.2.12 Other (1.A.5)

Source category 1.A.5 comprises the combustion-related emissions of the military sector. It is divided into the source categories 1.A.5.a "Stationary" and 1.A.5.b "Mobile".

3.2.12.1 Source category description (1.A.5)

CRF 1.A.5					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
All Fuels	l / t	CO ₂	0.97 %	0.14 %	-88.7 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	NMVOC	VOC	SO ₂
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties, gaseous fuels in %		-70 / +100				-30 / +50				
EF uncertainties, liquid fuels in %	± 5%	-30 / +50				-30 / +50				
EF uncertainties, solid fuels in %		-70 / +100				-70 / +100				
Distribution of uncertainties	N	L				L				
Method for EF determination	CS	CS				CS				

The source category "Other" is a key source of CO₂ emissions in terms of both emissions level and trend.

The following figure shows the emissions trend as of 1990.

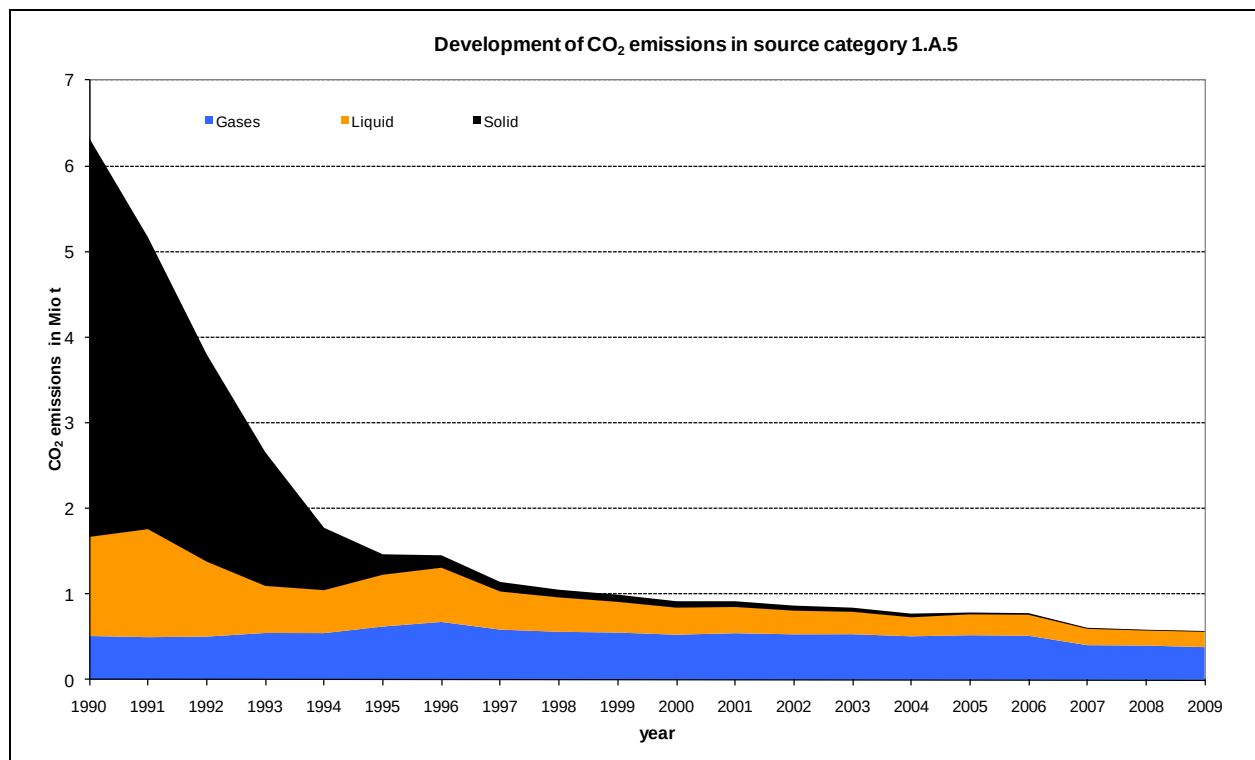


Figure 36: Development of CO₂ emissions in source category 1.A.5 [y axis: CO₂ emissions in million t; x axis: year; Gaseous; Liquid; Solid; CO₂ emissions by fuels]

A particularly large emissions reduction has occurred in source category 1.A.5. It is due a) to the closure of many military facilities and b) to marked changes in fuel inputs in stationary combustion systems. A trend is occurring in which gaseous and liquid fuels are supplanting solid fuels.

3.2.12.2 Methodological issues (1.A.5)

Activity data

The Energy Balance of the Federal Republic of Germany (AGEB) provides the basis for the activity data used. Since the Energy Balance does not provide separate listings of military agencies' final energy consumption as of 1995 – and includes that consumption only in line 67, under "commercial, institutional and other consumers" – additional sources of energy statistics had to be found for source category 1.A.5.

For source category **1.A.5.a**, use is made of data of the Federal Ministry of Defence (BMVg, 2010), which has reported the "Energy input for heat production in the German Federal Armed Forces", by fuels and for 2000-2009, to the Federal Environment Agency. Those figures are deducted from the figures in Energy Balance line 67 (commercial, institutional) and are reported in 1.A.5, rather than in 1.A.4. For the 2008 report year, use of wood in source category 1.A.5.a has been reported for the first time.

Until 1994, military fuel-consumption (diesel fuel and petrol) and aircraft-fuel-consumption (jet kerosine) data for source category **1.A.5.b** were taken from the Energy Balances. Since the Energy Balances lack separate data for the military sector, for subsequent years the Official Mineral Oil Statistics for the Federal Republic of Germany, published by the Federal Office of Economics and Export Control (BAFA), are used (BAFA, 2010). The consumption figures in

that source, which are given in units of 1,000 t, are converted into TJ on the basis of the pertinent listed net calorific values.

In the present report, inputs of lubricants, and the CO₂ emissions resulting from co-combustion of lubricants, are being included for the first time. For all years as of 1993, the underlying data on domestic deliveries to military agencies have been taken from the official mineral-oil data of the Federal Office of Economics and Export Control (BAFA). For the years 1990 through 1992, extrapolation has been carried out on the basis of trends in fuel inputs.

Emission factors

The database for the emission factors used for source category **1.A.5.a** consists of the results of a research project carried out by the University of Stuttgart, under commission to the Federal Environment Agency (STRUSCHKA, 2008). Within that project, device-related and source-category-specific emission factors for combustion systems in military agencies were calculated, with a high level of detail, for all important emissions components for the reference year 2005. The method used to determine the factors conforms to that described for source category 1.A.4. Table 63 shows the sectoral emission factors used.

With regard to the CO₂ emission factors used for the military transports considered under **1.A.5.b**, the reader's attention is called to the documentation in Annex Chapter 18.6 on "CO₂ emission factors". In general, the same country-specific values are used in this context that are used for the road-transport sector (diesel fuel, petrol, lubricants) and for the civil aviation sector (jet kerosene, avgas). For methane and nitrous oxide, country-specific values are also used for ground transports and for use of avgas. For jet kerosene, IPCC default figures are used, in light of the fact that the aircraft used by the sector differ strongly from those used in civil aviation. For CO₂ from co-combustion of lubricants, an IPCC default figure of 80,000 kg CO₂/TJ is currently being used. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Table 63: Sectoral emission factors for the military sector

Military	CH ₄	N ₂ O
	[kg/ TJ]	
- Stationary combustion in offices		
Hard coal	2.0	4.8
Lignite briquettes	242	0.37
Heating oil EL	0.017	0.56
Natural gas	0.042	0.29
- Military transports		
Diesel fuel	6.0	1.0
Petrol	37.0	3.7
Heavy-grade turbine fuel (jet kerosene)	0.5	2.0
Avgas	8.2	2.3
Lubricants	IE	IE

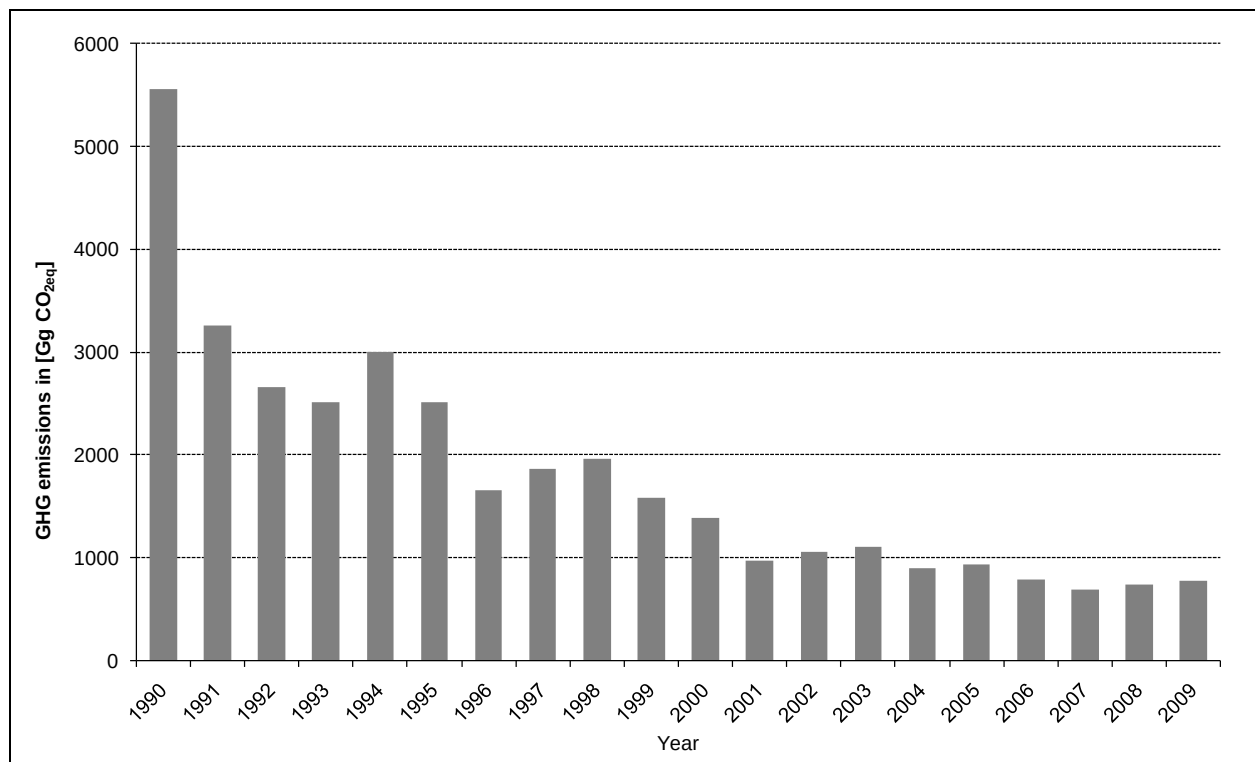


Figure 37: Development of greenhouse-gas emissions in military transports, 1990 – 2009

3.2.12.3 Uncertainties and time-series consistency (1.A.5)

Information regarding the uncertainties for the emission factors is provided in the description for source category 1.A.4. Annex 2 Chapter 13.6 in the NIR 2007 describes how the uncertainties for the activity data were determined.

3.2.12.4 Source-specific quality assurance / control and verification (1.A.5)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.2.12.5 Source-specific recalculations (1.A.5)

In the **stationary sector (1.A.5.a "Stationary")**, only slight recalculations, necessitated by updating of net calorific values, were required for the years 2007 and 2008.

For the area of **military transports (1.A.5.b "Mobile")**, recalculations were carried out for the entire time series, to take account of first-time inclusion of CO₂ emissions from co-combusted lubricants. The following two tables provide an overview of the calculated co-combusted quantities, the resulting CO₂ emissions and the impacts of the emissions on the entire sub- source category 1.A.5.b.

Table 64: Trends for lubricants co-combusted in category 1.A.5.b, and the resulting CO₂ emissions (now being reported for the first time) as of 1990

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Energy input	[TJ]	157.50	54.42	14.46	0.62	0.66	0.70	1.54	0.82
CO ₂ emissions	[Gg]	12.60	4.35	1.16	0.05	0.05	0.06	0.12	0.07

Table 65: Impacts on total emissions reported in 1.A.5.b

Reported in	Units	1990	1995	2000	2005	2006	2007	2008
Resubmission 2010	[Gg CO ₂ equivalent]	5550.35	2514.30	1383.38	928.64	780.92	692.77	734.45
Submission 2011		5562.95	2518.65	1384.54	928.69	780.97	692.83	734.57
Absolute difference		+ 12.60	+ 4.35	+ 1.16	+ 0.05	+ 0.05	+ 0.06	+ 0.12
Relative difference	[%]	+ 0.23	+ 0.17	+ 0.08	+ 0.01	+ 0.01	+ 0.01	+ 0.02

3.2.13 Military

Emissions from international deployments by the Federal Armed Forces, under a UN mandate, are not recorded as a separate activity for purposes of German emission inventories. Such recording will be again be a matter for discussion in the framework of the National Emissions Reporting System. For various reasons, the relevant required activity data are not provided.

This practice does not lead to any omissions in the inventories, since the fuel inputs associated with such deployments are included in national military consumption figures.

The basis for activity data for military fuels consists of the Official Mineral Oil Statistics for the Federal Republic of Germany (BAFA, 2010).

In the CSE, source category 1.A.5 includes, under stationary sources, heat production of military agencies; under mobile sources, it includes military transports and aviation.

3.3 Fugitive emissions from fuels (1.B)

During all stages of fuel production and use, from extraction of fossil fuels to their final use, fuel components can escape or be released as fugitive emissions.

While methane is the most important emission within the source category "solid fuels", fugitive emissions of oil and natural gas also include substantial amounts of carbon dioxide and NMVOC. Source category 1.B. is not a source for fluorinated gases.

Carbon dioxide emissions have decreased by 3 % with respect to 1990. The important factors in this development include processing of acid gas (1.B.2.b.ii) and flaring (1.B.2.c).

Emissions of **nitrous oxide** originate in flaring (1.B.2.c) in oil and gas production, and in gas processing. They are very low. As a result of decreases in natural gas production, emissions decreased by 18 % with respect to 1990.

Methane emissions have been influenced primarily by sharp emissions decreases in the area of active mining (1.B.1.a) – caused mainly by reduced mining activity – and by increasing use of methane from decommissioned mines (1.B.1.c). With respect to 1990, methane emissions in category 1.B have decreased by over 63 %.

Emissions of volatile organic compounds (**VOC**) have decreased by nearly 58 % since 1990. The decrease is due to implementation of the Technical Instructions on Air Quality Control (TA-Luft 2002), to decreases in emissions from petrol storage and from fuelling of motor vehicles (1.B.2.a.v) – as a result of implementation of the 20th and 21st Ordinances on the Execution of the Federal Immission Control Act (BimSchV) – and to reduced petrol consumption. Figure 38 shows trends for non-methane-containing volatile organic compounds (**NMVOC**).

Sulphur dioxide emissions have decreased by over 67 % since 1990. The sharp reductions in such emissions seen especially at the beginning of the 1990s were due especially to closures in the eastern German industrial sector, to use of improved filters and to switching from lignite to other fuels. In subsequent years, decreasing production of hard-coal coke (1.B.1.b) and improved filter technologies in desulphurisation of natural gas (1.B.2.b.ii) had the largest effects on emissions.

Carbon monoxide emissions have decreased by nearly 69 % since 1990, primarily as a result of decreasing production of hard-coal coke (1.B.1.b) and discontinuation of city-gas deliveries via the public gas-distribution network (1.B.2.b.iv).

Additional details relative to sulphur dioxide, carbon monoxide and NMVOC are described in the "Informative Inventory Report", available at iir.umweltbundesamt.de. Those details are not presented in the present report, since those gases are not greenhouse gases.

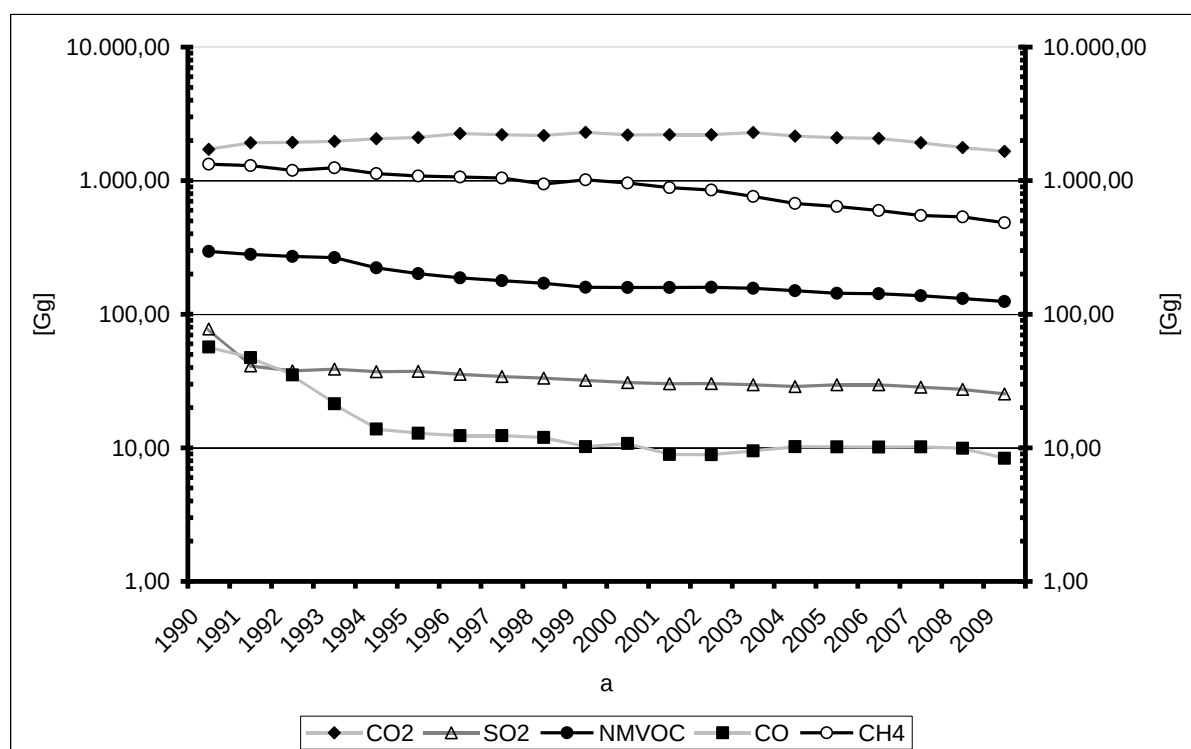


Figure 38: Emissions of CO₂, CH₄, NMVOC, SO₂ and CO in source category 1.B.²⁵.

3.3.1 Solid fuels (1.B.1)

The source category "Solid fuels" (1.B.1) consists of three sub- source categories – the source category "Coal mining" (1.B.1.a), the source category "Coal transformation" (1.B.1.b) and the source category "Other" (1.B.1.c).

Table 66 presents the scheme for source category allocation and the relevant calculation methods (Table 67).

²⁵ For the sake of clarity, N₂O emissions are not included here. They decreased from 3,555kg in 1990 to 2,914kg in 2009.

Table 66: Allocation of methane emissions to areas of the CRF

Source category		Included emissions
1.B.1.a. Coal mining		
	i. Underground mining	
	Mining activities	Emissions from active underground hard-coal mining. The total emissions from pit gas flows and pit-gas removal are reduced by the amount of pit gas used.
	Follow-up mining activities	Emissions from processing, storage and transport of hard coal
	ii. Open-pit mining	
	Mining activities	Emissions from active open-pit lignite mining. Here, the entire potential methane content of German lignite is used as the basis – this methane is assumed to be emitted, in its entirety, during mining. Any later emissions of methane, during further processing, are thus already taken into account. No pit-gas collection or use takes place in open-pit mining.
	Follow-up mining activities	No separate listing – the emissions are already included in "mining activities"
1.B.1.b. Coal transformation – processing		Emissions from coal processing. This area takes account of specific emissions that occur in hard-coal processing (hard-coal coke, hard-coal briquettes). Emissions from lignite processing (lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate) are already included in 1.B.1.a.ii "Mining activities". The assumed activity data covers the total for all processed products from hard coal and lignite.
1.B.1.c. Other		
	Decommissioned coal mines	Methane emissions for decommissioned hard-coal mines are listed here. No methane emissions from decommissioned lignite mines are recorded. Specification of an activity rate is not required.

In keeping with allocation of emissions to the various areas of the CRF table for "1.B.1 – Fugitive emissions from solid fuels", the following Table 67 presents calculated values for 2009 activity data, along with information regarding the origin of the data.

Table 67: Calculation of methane emissions from coal mining for 2009

			Activity data [Mt]	CH ₄ emissions [Gg]
1.B.1.a. Coal mining			183.67 (= 1.B.1.a.i + 1.B.1.a.ii)	(= 1.B.1.a.i + 1.B.1.a.ii) = 129.76+1.87 = 131.63
i.	Underground mining	13.766 ²⁶ Hard-coal production 1)	= mining and follow-up mining- related activities = 121.83 + 7.93 = 129.76	
	Mining activities		= AD * EF = 13.766 * 8.85 = 121.83	
	Follow-up mining activities		= 7.93	
	ii.	Open-pit mining	169.9 Lignite mining 1)	= mining activities = 1.87
		Mining activities		= AD * EF = 169.9 * 0.011 = 1.87
		Follow-up mining activities		(included in 1.B.1.a.ii) IE
1.B.1.b. Coal transformation – processing			12.52 Total for processed products 2) 1)	AD _{H-coal production} *EF _{H-coal production} + AD _{lignite production} *EF _{lignite production} = 6.77 * 0.049 + 5.75 * 0 = 0.33
1.B.1.c. Other				= Decommissioned coal mines = 3.6
	Decommissioned coal mines	NO	Potential emissions, minus gas usage = 3.6	

1) pursuant to STATISTIK DER KOHLENWIRTSCHAFT (2010)

2) Hard-coal coke, hard-coal briquettes, lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate

3.3.1.1 Coal mining and handling (1.B.1.a)

3.3.1.1.1 General description of the source category Coal mining and handling (1.B.1.a)

CRF 1.B.1.a										
Key source by level (l) / trend (t) / Tier 2 (T2)			Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend				
Solid Fuels			I / t / T2	CH ₄	1.51 %	0.29 %	-85.0 %			
Schadstoff	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %		-								
Distribution of uncertainties		-								
EF-determination method		T2								

The source category "Coal mining and handling" is a key source of CH₄ emissions in terms of both emissions level and trend.

For the source category Coal mining and handling (1.B.1.a), the only truly significant emissions tend to be those from ongoing extraction (coal-seam methane, CSM). Emissions

²⁶ Not including small mines

from hard-coal processing are listed in source category 1.B.1.b, while emissions from decommissioned hard-coal mines (coal-mine methane, CMM) are listed in source category 1.B.1.c. This breakdown applies only to hard coal. For lignite, the chosen calculation procedure places all emissions in 1.B.1.a(ii).

During coal production, transport and storage, methane can escape from coal and the rock surrounding it. The amount of methane released depends primarily on the amount of methane stored in the coal. All of the emissions that result from this relationship – but not the greenhouse gases caused by coal combustion – are to be recorded in this source category.

In the mining sector, a distinction is made between open-pit mines, in which raw materials are extracted from pits open to the surface, and closed-pit mines, in which seams are mined underground. In Germany, hard coal is mined in 3 coal fields (Revier), in a total of 6 mines (all closed-pit), while lignite is mined in 4 coal fields, primarily with the open-pit method (11 pits; since 2003 all lignite mining has been open-pit).

In underground coal mining, ventilation systems are used to keep mine methane concentrations within safe limits for mining. Such systems can emit significant amounts of methane into the atmosphere as they ventilate the air and gas mixtures prevailing in underground mines. Hard-coal mining is the principal source of fugitive emissions of CH₄. Some methane is suctioned off directly from seams and ancillary rocks and used, as pit gas.

Hard-coal production in 2009 amounted to some 14 million t of marketable production. Lignite production in 2009 totalled 170 million t (STATISTIK DER KOHLENWIRTSCHAFT, 2010). As a result, hard-coal production decreased by about 18 % from the previous year, while lignite production decreased by about 2.8 %.

Methane emissions from hard-coal mining have decreased since 1990 as a result of decreasing production and increasing use of pit gas. Emissions from open-pit lignite mining have also decreased, also as a result of production decreases.

3.3.1.1.2 Methodological issues (1.B.1.a)

For calculation of CH₄ emissions from coal mining, emissions are determined for the areas of underground hard-coal mining, pit-gas use, hard-coal storage and open-pit lignite mining.

Emissions from underground hard-coal mining are calculated pursuant to the Tier 3 method, in a procedure that meets requirements pertaining to mine-specific emissions determination. For safety reasons, gas compositions and air flows are measured continuously in all pit systems. The resulting data is used to determine levels of methane emissions. The association of the German hard-coal mining industry (Gesamtverband Steinkohle) aggregates the individual measurements to determine total methane amounts. It then makes the resulting statistics available for the inventory (STATISTIK DER KOHLENWIRTSCHAFT, 2010). Expert review is carried out by the competent state supervisory authority (the mining authority – Bergamt).

An implied emission factor (IEF) of 8.85 kg/t (2009) has been derived from the total methane emissions figures and from the relevant activity data for hard-coal mining. This calculation takes pit-gas usage into account. The measurements show only actually emitted methane amounts.

For calculation of CH₄ emissions from hard-coal storage, the activity data for hard-coal production is used as a basis and then multiplied by the emission factor of 0.576 kg/t. That

emission factor has been taken from a study of the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI) (1993).

Emissions from open-pit lignite mining have been calculated, in keeping with the Tier 2 approach, pursuant to the relevant equation in the IPCC Reference Manual (IPCC, 1996b).

The activity data (crude lignite) has been taken from the STATISTIK DER KOHLENWIRTSCHAFT (2010). According to the DEBRIV German lignite-industry association (Deutscher Braunkohlen-Industrie-Verein e.V; DEBRIV 2004), an average emission factor of $0.015 \text{ m}^3 \text{ CH}_4/\text{t}$ (corresponds to $0.011 \text{ kg CH}_4/\text{t}$) is assumed. This emission factor is based on a 1989 study of RWE Rheinbraun AG (DEBRIV, 2004) and is documented by publications of the Öko-Institut e.V. Institute for Applied Ecology and of the DGMK (German Society for Petroleum and Coal Science and Technology; research report / Forschungsbericht 448-2, 1992). This value is considerably lower than the emission factor used prior to 2005, $0.11 \text{ m}^3 \text{ CH}_4/\text{t}$, which was derived from the EF for American hard lignite. Such American EF cannot be applied to German soft lignite, since the latter's temperature did not exceed 50°C during the coalification process. Significant methane releases occur only at temperatures above 80°C .

No lignite storage takes place; usage is "mine-mouth", i.e. extracted coal is moved directly to processing and to power stations.

3.3.1.1.3 Uncertainties and time-series consistency (1.B.1.a)

The uncertainties in the activity data result primarily from inaccuracies in weighing of extracted coal. Via surveys of experts carried out during the NASE workshop of 11/2004, the relevant error has been quantified as $<3 \%$.

Uncertainties in calculation of methane releases result from inaccuracies in methane measurements. As a result of the facts that underground measurements of methane concentrations are carried out primarily for safety reasons, and that their most precise measurement range does not fall within the range of common gas-release concentrations, the available measuring equipment can be expected to have a technical measurement inaccuracy of about 10% .

Methane releases from hard coal, during storage and transport, fluctuate considerably in keeping with storage duration and grain-size distribution. An uncertainty of 15% is assumed (LANGE 1988 / BATZ 1995, along with information communicated personally at the NASE workshop 11/2004).

The emission factor used for calculating methane emissions from lignite production is based on maximum methane content levels and thus represents the upper limit of possible methane emissions. It thus already includes possible emissions from transport and storage. Numerous studies have shown that a negative uncertainty of -33% must be assumed (DEBRIV / DGMK research report / Forschungsbericht 448-2, DGMK 1992).

Apart from the emission factor for pit-gas release from underground hard-coal mining, the emission factors are consistent in the time series, within the meaning of comparability throughout the time series. For the activity data, a consistent source is used throughout the entire time series.

3.3.1.1.4 Source-specific quality assurance / control and verification (1.B.1.a)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

For underground hard-coal mining, the IPCC Reference Manual (1996b) recommends emission factors on the order of 10 to 25 m³/t. Conversion of the German emission factors, using a conversion factor of 0.67 Gg/10⁶ m³ (pursuant to IPCC Reference Manual, 1996b: at 20° C, 1 atmosphere) yields the individual values listed in Table 68. When production, storage and deductible pit-gas use are combined in one emission factor, the resulting value per tonne of coal (marketable production) lies within the recommended range.

Table 68: Emission factors for CH₄ from coal mining, for 2009

Emission factors	Hard coal (Steinkohle)		Lignite (Braunkohle)	
	EF m ³ CH ₄ /t	EF kg/t	EF m ³ CH ₄ /t	EF kg/t
CH ₄ from extraction	19.66	13.17	0.016	0.011
CH ₄ from extraction, minus pit gas used	13.21	8.85	-	-
CH ₄ from storage	0.87	0.58	-	-
CH ₄ from mining (extraction and storage, minus pit-gas used)	14.08	9.43	0.016	0.011

The IPCC Reference Manual (1996b) does not recommend any specific emission-factor levels for open-pit lignite mining.

In the framework of verification for the 2005 report, various data sources for activity data in coal mining, and the relevant EF used, were compared with the corresponding sources and EF of other countries.

A by-country comparison of specific emission factors for underground coal mining shows a broad range, with Germany in the lower part of the range, in a position comparable to that of the Czech Republic. France's EF lies considerably higher within the range, while Poland's is considerably lower. Both of these countries' EF lie outside of the UNFCCC's default values.

A by-country comparison of specific emission factors for open-pit coal mining shows that Poland, France (where production was discontinued in 2002) and Germany have relatively low emission factors that are below the default values. The reason for this is that the relevant coal in these countries has very low methane content, as a result of its degree of coalification and its geological history. Consequently, suitably low emission factors have to be applied to it. The comparison value for the Czech Republic is considerably higher, since its coal is not the "lignite" found in Germany, which has a low degree of coalification; instead, its coal is largely "sub-bituminous coal", which has a higher degree of coalification and higher methane content.

3.3.1.1.5 Source-specific recalculations (1.B.1.a)

No recalculations are required.

3.3.1.1.6 Source-specific planned improvements (1.B.1.a)

No improvements are planned at present.

3.3.1.2 Solid fuel transformation (1.B.1.b)

3.3.1.2.1 Source category description (1.B.1.b)

CRF 1.B.1.b										
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)		1990 – contribution to total emissions			2009 – contribution to total emissions			Trend	
	- / -									
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		CS								

The source category *Solid fuel transformation* is not a key source.

3.3.1.2.2 Methodological issues (1.B.1.b)

The IPCC Reference Manual does not describe any methods for this source category (IPCC 1996b, p.1.110f). The country-specific method that is used is based on activity data from the STATISTIK DER KOHLENWIRTSCHAFT (2010) and on corresponding emission factors.

Production of low-temperature lignite coke took place solely in the new German Länder and, for purposes of the inventory, is of relevance only for the base year. Production was discontinued after 1992.

Calculation procedure

Emissions from hard coal coke production have been calculated pursuant to the Tier 2 approach, in a manner similar to that of the IPCC Reference Manual's equation for CH₄ emissions from coal mining:

Emissions [Gg CH₄] =

EF [m³ CH₄ /t] * AD_{processing product} * conversion factor [Gg/10⁶m³]

The activity data for hard-coal-coke production has been taken from the STATISTIK DER KOHLENWIRTSCHAFT (2010).

The methane emission factor used for calculation of CH₄ emissions from hard-coal-coke production (coking plants) is 0.049 kg methane per tonne of hard-coal coke (DMT 2005). It is used for the entire time series.

In the CSE, the source category "coal transformation" is covered by the time series for hard-coal-coke production (coking plants).

No emissions are to be expected from processed lignite products, since the EF used for 1.B.1.a corresponds to the gas content of the lignite occurring in Germany.

3.3.1.2.3 Uncertainties and time-series consistency (1.B.1.b)

The emission factors remain at the same level in the time series and are thus consistent within the meaning of comparability throughout the time series. For the activity data, a consistent source is used throughout the entire time series.

3.3.1.2.4 Source-specific quality assurance / control and verification (1.B.1.b)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

In consideration of emission factors, the IPCC conversion factor of 0.67 Gg/10⁶m³ at 20°C and 1 atmosphere (IPCC et al; 1997, Reference Manual, p. 1.108) should be applied to the units used in Germany: normal cubic metres at 1.01325 bar and 0°C (DIN 2004, DIN No. 1343). The German practice of using normal cubic metres should also be noted in consideration of the IPCC default EF, and of figures from other published sources. In use of EF data published in Germany, it is assumed that the relevant figures use normal cubic metres (substantiated via survey of experts at the NaSE workshop 11/2004)

The guideline figures are oriented to 20°C and 1,013 mbar. In keeping with methane's isobaric proportionality, the factor 1.07 can be used to convert Nm³ into m³.

Conversion factor, normal cubic metres ⇔ kilogrammes:

$$0.717 \text{ Nm}^3/\text{kg} \text{ (1.01325 bar, 0°C)} = 0.67 \text{ Gg}/10^6\text{m}^3 \text{ (20°C, 1 atmosphere)} * 1.07 \text{ Nm}^3/\text{m}^3$$

3.3.1.2.5 Source-specific recalculations (1.B.1.b)

No recalculations are required.

3.3.1.2.6 Source-specific planned improvements (1.B.1.b)

No improvements are planned at present.

3.3.1.3 Other (1.B.1.c)

3.3.1.3.1 Source category description (1.B.1.c)

CRF 1.B.1.c										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions		2009 – contribution to total emissions		Trend			
Solid Fuels	- / t	CH ₄	0.15 %		0.01 %		-95.8 %			
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		CS								

The source category *Other* is a key source of CH₄ emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-95.8 %), and thus an extremely low emissions level has been attained (in 2009, emissions amounted to 2.2 % of the contribution of the smallest key source identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key sources.

Emissions from decommissioned hard-coal mines play a significant role in this sub- source category. As well as active mines, decommissioned hard coal mines (degassing) represent another relevant source of fugitive CH₄ emissions.

When a hard-coal mine is decommissioned, methane can escape from neighbouring rock, and from coal remaining in the mine, into the mine's network of shafts and passageways. Since the mine is no longer artificially ventilated, the methane collects and can then reach the surface via gas pathways in the overlying rock or via the mine's own shafts and passageways.

Such pit gas was long seen primarily as a source of danger (in active hard-coal mines) and as a negative environmental factor (in decommissioned hard-coal mines). Recently, increasing attention has been given to the gas' positive characteristics as a fuel (use for energy recovery). In the past, use of pit gas was rarely cost-effective (as shown by the example of the state of North Rhine – Westphalia). This situation changed fundamentally in 2000 with the Renewable Energy Sources Act (EEG). Although pit gas is a fossil fuel in finite supply, its use supports climate protection, and thus the gas was included in the EEG. The Act requires network operators to accept, and provide specified compensation for, electricity generated with pit gas and fed into the grid. As a result, the AD_{CMM collection} increased from 1.429 million m³ in 1998 to 267 million m³ in 2009. The reason for the lower rate of pit-gas use, with respect to the previous year, is that the production of such gas dropped.

The following figure highlights the law's impacts on actual emissions. Such emissions have been decreasing considerably since 2000, primarily as a result of steadily increasing use of pit/mine gas from decommissioned mines. The gas quantities being used from active mines have been decreasing, since the sector's gas production has been decreasing as decommissioning of numerous mines has continued. In qualitative terms, the gas quantity being used is still very high.

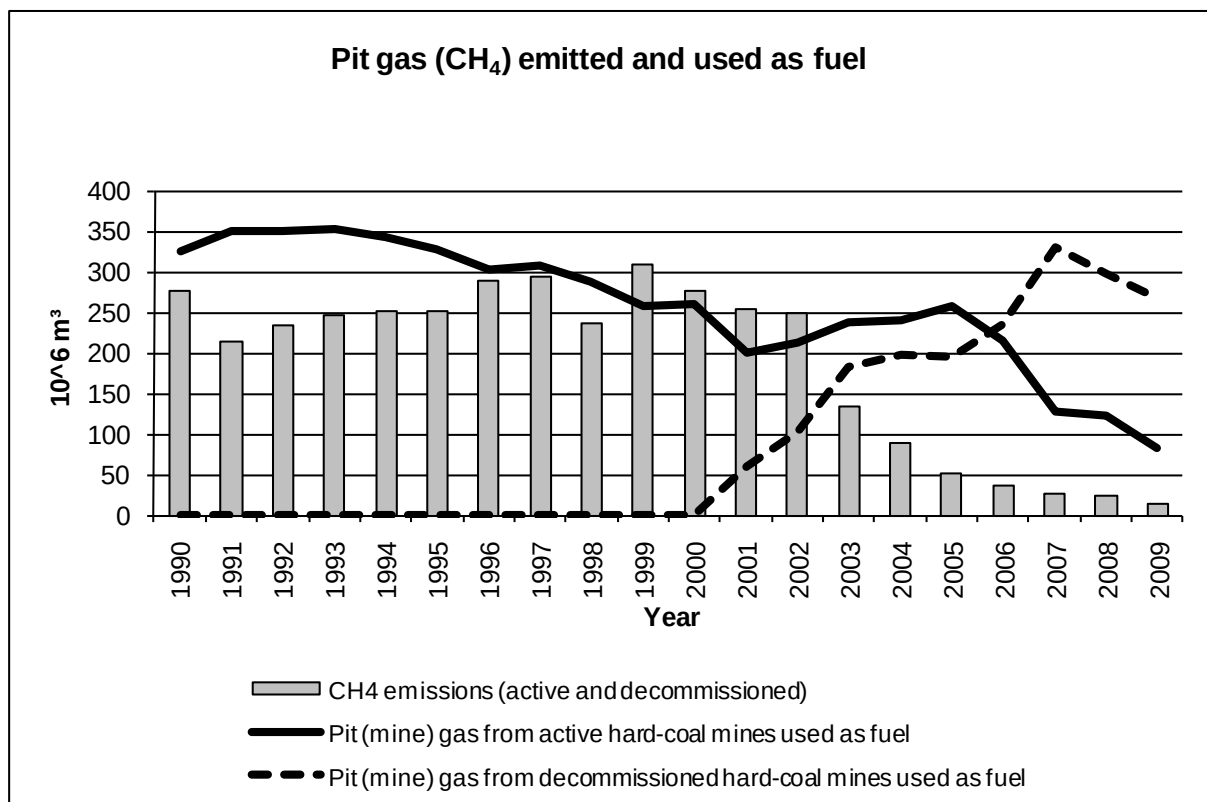


Figure 39: Comparison of used and emitted CH₄ from pit gas

In emissions reporting, quantities of pit gas used must be determined separately from released quantities of CH₄, must be broken down by active and decommissioned mines and

must then be listed in source category 1.A. as energy production with relevant emissions (i.e. must be suitably offset).

3.3.1.3.2 Methodological issues (1.B.1.c)

The IPCC Reference Manual does not describe any methods for the sub- source category "Other" (IPCC et al, 1997, Reference Manual, p.1.110f).

As well as active mines and coal processing, decommissioned hard-coal mines (degassing) represent another relevant source of fugitive CH₄ emissions.

No emissions are to be expected from decommissioned open-pit lignite mines, since the EF used for 1.B.1.a corresponds to the gas content of the lignite occurring in Germany. Lignite that remains in decommissioned open-pit mines does not continue to release gas (DEBRIV).

This source category is subdivided into the following sub-areas:

- Underground mines, decommissioned hard-coal mines
- Decommissioned hard-coal mines, with pit-gas use

3.3.1.3.3 Uncertainties and time-series consistency (1.B.1.c)

It is quite practicable to determine the quantities of methane used; an uncertainty of < 3 % due to measurement inaccuracies is assumed. The total quantities of available methane in question have been estimated solely on the basis of experts' knowledge. In this area, an uncertainty of 50 % has been assumed.

The time series for potential methane emissions and amounts of methane used both originate from reliable sources and are consistent throughout.

3.3.1.3.4 Source-specific quality assurance / control and verification (1.B.1.c)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

In consideration of emissions, it must be noted that the IPCC conversion factor is 0.67 Gg/10⁶ m³ at 20°C and 1 atmosphere (IPCC Reference Manual, 1996b: p. 1.108), while figures in Germany are given in normal cubic metres at 1.01325 bar and 0°C (DIN 2004, DIN No. 1343). Users of emissions data published in Germany should assume that the relevant figures are in normal cubic metres.

The IPCC Guideline figures are oriented to 20°C and 1,013 mbar. In keeping with methane's isobaric proportionality, the factor 1.07 can be used to convert Nm³ into m³.

3.3.1.3.5 Source-specific recalculations (1.B.1.c)

Recalculations were carried out on the basis of updated figures from the German hard-coal mining association (Gesamtverband Steinkohle - GVSt). Partial use of by-product methane has been in progress since 1998. Such use led to a considerable reduction of methane emissions in source category 1.B.1.c by 2009.

The listed emissions quantity consists of a highly uncertain estimate of total emissions from decommissioned mines (experts' assessment: ± 50 %, source: Deutsche Montan Technologie GmbH, DMT 2005), minus the quantity of methane used.

3.3.1.3.6 Source-specific planned improvements (1.B.1.c)

Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at 300 million m³ and assumed that some 5 million m³ of these escape into the atmosphere. Since this figure is subject to large uncertainties, a research project on "Potential for release and use of pit gas" is working to improve it. Fugitive releases at ground surface amount to no more than 0.02 % of total gas releases.

3.3.2 Oil and natural gas (1.B.2)

The overarching category 1.B.2 comprises a total of 14 source categories. These categories are further subdivided, in keeping with oil and gas industry criteria, and in keeping with the industry's process chains. In the emissions database, data on fugitive emissions from oil and natural gas are included with data for the pertinent source categories and sub-source categories. Emissions of source categories under the overarching CRF category 1.B.2 have been determined primarily via the Tier-2 method (IPCC) or the "simpler methodology" (EMEP).

To improve emissions reporting, and in order to fulfil a range of different reporting requirements, a new approach relative to the IPCC and EMEP methods was developed in the main process "Definition of the bases for calculation" (cf. UBA 2005d: p. 24) before the inventory was prepared. This approach for determining emissions, applied under the **working title "logistics"**, was described in detail in the NIR 2008.

In efforts to improve the emission factors in source categories 1.B.2.a.i, 1.B.2.a.ii, 1.B.2.b.ii, 1.B.2.b.iv, 1.B.2.c.ii and 1.B.2.c.iii, both quantitatively and qualitatively, a research project of Müller-BBM²⁷, conducted in 2009 (FKZ 360 16 012), showed that use of emission factors of other reporting countries (which use had previously been considered) "could by no means be recommended" – since, so the project, such factors are not applicable to the circumstances prevailing in Germany. For this reason, the default values from the IPCC Guidelines are used.

3.3.2.1 Recalculations and time-series consistency (1.B.2 all)

New findings in the area of storage of petroleum and petroleum products, from a research project pursuant to Müller-BBM (sub-project on storage facilities, 2009b), have led to recalculations in the area of CH₄ and NMVOC emissions in 1.B.2.a.vi. In addition, CH₄ and NMVOC emissions in 1.B.2.a.v, in the area of handling of petrol at petrol stations, have been calculated with the help of more-specific emission factors.

In the area of flaring (1.B.2.c), emissions from flares in refineries have been taken into account with the help of a relevant new CO₂ emission factor.

²⁷ Müller-BBM (2009a) Inventarverbesserung 2008, Verbesserung und Ergänzung der aktuellen Inventardaten (Inventory improvement 2008, improvement and supplementation of current inventory data), IPCC Category (1996) 1.B.2 Diffuse emissions from petroleum and natural gas, Bericht Nr. (report number) M 76 595/4, UBA FKZ 360 16 012, 136 p.

Table 69: Recalculations for carbon dioxide and methane in source category 1.B.2

1.B.2 Oil and natural gas	CO ₂ [Gg]		CH ₄ [Gg]	
	1990	2008	1990	2008
Submission 2010	1,442.53	1,465.42	363.80	343.65
Submission 2011	1,715.10	1,772.08	362.85	352.53
Difference	+ 19 %	+ 21 %	0 %	+ 3 %

As a result of remarks made by the Expert Review Team (ERT) during the In-Country Review 2010, nitrous oxide emissions were recalculated with emission factors from the Good Practice Guidance 2000 (Tabelle 2.16) for flaring in oil and gas production and in gas processing.

3.3.2.2 Planned improvements (1.B.2, all)

The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.iii-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity data for these categories.

3.3.2.3 Oil (1.B.2.a)

CRF 1.B.2.a.i					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
- / -					

3.3.2.3.1 Oil, Exploration (1.B.2.a.i)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	D	D	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
EF-determination method										

The source category 1.B.2.a.i "Oil, exploration" is not a key source.

3.3.2.3.1.1 Source category description (1.B.2.a.i)

This source category's emissions consist of emissions from activities of drilling companies and of other participants in the exploration sector. Gas and oil exploration takes place in Germany. In 2009, 17 successful drilling operations, with a total drilling distance of 66,201 m, were carried out (the annual report of the WEG association of oil and gas producers (Wirtschaftsverband Erdöl- und Erdgasgewinnung - WEG 2010): Table on drilling success, p. 58). The underlying exploration statistics do not differentiate between drilling for oil and drilling for gas.

3.3.2.3.1.2 Methodological issues (1.B.2.a.i)

Emissions for successful drilling (WEG, 2010) are calculated on the basis of the default factor pursuant to the IPCC Guidelines (1996) for CO₂, 0.48 kg / drill, and of the default factor for methane, 64 kg / drill.

3.3.2.3.1.3 Uncertainties and time-series consistency (1.B.2.a.i)

The uncertainties for the emission factors in the source category are in keeping with the uncertainties for the default factors (IPCC GPG 2000; Chapter 2.7.1.6).

3.3.2.3.1.4 Source-specific quality assurance / control and verification (1.B.2.a.i)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of quality assurance were taken into account in determination and documentation of emissions.

Due to a lack of country-specific data, an external assessment (Müller-BBM, 2009a) was commissioned. In its source-category analysis, that assessment found that the default factors are applicable to Germany.

3.3.2.3.1.5 Source-specific recalculations (1.B.2.a.i)

No recalculations are required.

3.3.2.3.1.6 Source-specific planned improvements (1.B.2.a.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.2 Oil, Production (1.B.2.a.ii)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	D	D	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
EF-determination method										

The source category 1.B.2.a.ii "Oil, production" is not a key source.

3.3.2.3.2.1 Source category description (1.B.2.a.ii)

This source category's emissions are produced in the petroleum industry's extraction (crude oil) and pre-treatment of raw materials (petroleum).

According to the annual report of the WEG German oil and gas industry association (WEG, 2009), German petroleum extraction in 2010 amounted to some 2.8 million tonnes.

Because Germany's oil fields are old, oil production in Germany is highly energy-intensive (thermal extraction, operation of pumps to inject water into oil-bearing layers). The emission factors listed in the WEG report (2009) (CO₂, about 100 kg/t; CH₄, about 0.11 kg/t) include both emissions from external energy production (which is not a focus of reporting for this source category) and actual emissions from extraction. For this reason, the default emission factors for CO₂ and CH₄ pursuant to the IPCC Guidelines (1996) are used.

The first treatment that extracted petroleum (crude oil) undergoes in processing facilities serves the purposes of removing gases, water and salt from the oil. Crude oil in the form in which it appears at wellheads contains impurities, gases and water, and thus does not conform to requirements for safe, easy transport in pipelines. No substance transformations take place. Impurities – especially gases (petroleum gas), salts and water – are removed, in order to yield crude oil of suitable quality for transport in pipelines.

3.3.2.3.2.2 Methodological issues (1.B.2.a.ii)

The Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association (WEG) does not break down emissions by energy production and extraction. As a result, for this source category the default emission factors for CO₂ (0.313 kg/t) (= 0.27 kg/m³; the conversion factor is 1.16 m³/t) and CH₄ (1.624 kg/t) (= 1.4 kg/m³; the conversion factor is 1.16 m³/t) from the 1996 IPCC Guidelines are used.

3.3.2.3.2.3 Uncertainties and time-series consistency (1.B.2.a.ii)

In this source category, the uncertainty for the activity data is given as 5 to 10 %. The figures are based on estimates of WEG experts and national experts.

The uncertainties for the emission factors in the source category are in keeping with the uncertainties for the default factors (IPCC GPG 2000; Chapter 2.7.1.6).

3.3.2.3.2.4 Source-specific quality assurance / control and verification (1.B.2.a.ii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of quality assurance were taken into account in determination and documentation of emissions.

Analysis of the inventories of other countries (Müller-BBM, 2009a) has shown that, because certain information is lacking and there are overly large discrepancies in the values for the relevant criteria, the inventories' figures can neither be compared nor transferred.

3.3.2.3.2.5 Source-specific recalculations (1.B.2.a.ii)

No recalculations are required.

3.3.2.3.2.6 Source-specific planned improvements (1.B.2.a.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.3 Oil, Transport (1.B.2.a.iii)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	D	D	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
EF-determination method										

The source category 1.B.2.a.iii "Oil, transport" is not a key source.

3.3.2.3.3.1 Source category description (1.B.2.a.iii)

This source category's emissions are produced in activities of logistics companies and of operators of pipelines and pipeline networks, including pertinent facilities for storage of relevant materials – i.e. crude oil and intermediate petroleum products. Following first treatment, crude oil is transported to refineries.

Almost all transports of crude oil take place via pipelines. Pipelines are stationary and, normally, run underground. In contrast to other types of transports, petroleum transports are not interrupted by handling processes.

As of 2009, the Federal Republic of Germany's network of long-distance pipelines for crude-oil imports had a total length of 1,861 km and a throughput of about 101 million tonnes of crude oil (MWV, 2010, p. 38ff)

In 2005, Germany had a total of 3,331 km of crude oil pipelines. A total of 33.6 million tonnes of oil passed through them in that year (MWV, 2006, Mineralölversorgung mit Pipelines).

Pursuant to *FEDERAL STATISTICAL OFFICE* Fachserie 8, Reihe 4, Table 2.1, inland-waterway ships transported 14,600 t of crude oil in in 2009.

3.3.2.3.3.2 Methodological issues (1.B.2.a.iii)

Due to a lack of country-specific emission factors in the area of pipeline oil transports, the default emission factors from the IPCC Guidances (1996) for the Tier 1 method are used:

EF CH₄ – 6.75 g/t

EF CO₂ – 0.613 g/t

Experts have estimated the emission factor for NMVOC to be 60.75 g/t.

General information relative to fulfillment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. NIR 2008, Chapter 3.2.2.1, p. 205 ff).

3.3.2.3.3.3 Uncertainties and time-series consistency (1.B.2.a.iii)

The uncertainties for the emission factors in the source category are in keeping with the uncertainties for the default factors (IPCC GPG 2000; Chapter 2.7.1.6).

3.3.2.3.3.4 Source-specific quality assurance / control and verification (1.B.2.a.iii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Analysis of the inventories of other countries (Müller-BBM, 2009a) has shown that, because certain information is lacking and there are overly large discrepancies in the values for the relevant criteria, the inventories' figures can neither be compared nor transferred.

3.3.2.3.3.5 Source-specific recalculations (1.B.2.a.iii)

No recalculations are required.

3.3.2.3.3.6 Source-specific planned improvements (1.B.2.a.iii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.4 Oil, refining and storage (1.B.2.a.iv)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	-	CS	-	-	-	-	NO	NO	CS	CS
EF uncertainties in %		50								
Distribution of uncertainties		N								
EF-determination method										

The source category 1.B.2.a.iv "Oil, refining and storage" is not a key source.

3.3.2.3.4.1 Source category description (1.B.2.a.iv)

Refining

This source category's emissions consist of emissions from activities of refineries and of refining companies in the petroleum industry. Crude oil and intermediate petroleum products are processed in Germany. For the most part, the companies concerned receive crude oil for refining and processing. Such processing takes place in state-of-the-art plants. In 2009, a total of 14 crude-oil refineries, and 9 lubricating-oil and used-oil refineries, were in operation in Germany. The total crude-oil input was 113.2 million t in 2009. (MWV, 2010: p. 47).

Storage

Tank-storage facilities in refineries

Refinery tank storage systems are used to store both crude oil and intermediate and finished petroleum products. They thus differ from non-refinery tank storage systems in terms of both the products they store and the quantities they handle. The relevant emissions originate primarily in the conveyance and sealing systems used in refineries.

With regard to tank storage systems in refineries, interim results can be taken from the research project²⁸ "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV; Bereich Lageranlagen" ("Processing of data from emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act; the area of storage systems"; Müller-BBM, FKZ 3707 42 103/01, 2009).

Tank-storage facilities outside of refineries

Tank-storage facilities outside of refineries are used especially for interim storage of heating oil, petrol and diesel fuel. All in all, the storage capacity of petroleum-storage facilities in Germany amounted to 41,660,456 m³ in 2009 (BAFA, 2010).

Cleaning

Tanks are emptied and cleaned for purposes of tank inspections and repairs. In tank cleaning, a distinction is made between crude-oil tanks and product tanks. Because of the sediment deposits involved, cleaning of crude-oil tanks, in comparison to cleaning of product tanks, is a considerably more involved process. Product tanks contain no sedimentable substances and thus are cleaned only when the products they contain are changed.

Pursuant to a research report of the German Society for Petroleum and Coal Science and Technology (DGMK; research report 499-01 (2000)), a total of 30 to 35 cleaning operations for crude-oil tanks in 2000 produced some 50,000 kg of NMVOC emissions. Emissions from product-tank cleaning are estimated to amount to 666 kg of NMVOC. No more recent pertinent findings are currently available.

²⁸ Müller-BBM (2009b): "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCC- und UNECE-Berichterstattung; Bereich Lageranlagen", Bericht Nr. (report number) M74 244/7, UBA FKZ 3707 42 103/01, 31 p.

3.3.2.3.4.2 Methodological issues (1.B.2.a.iv)

Refining

With regard to emissions of NMVOC and CH₄ in the area of processing, the activity data is taken from the "Petroleum Data" ("Jahresbericht Mineralöl-Zahlen" of the Association of the German Petroleum Industry (Mineralölwirtschaftsverband e.V.; MWV). The emission factors used are based on experts' estimates.

The SO₂ emissions occurring in desulphurisation of crude oil are calculated as the product of the activity data (quantity of sulphur produced by refineries) and the estimated emission factor (IZT, 2003).

Storage

Tank-storage facilities in refineries

Pursuant to Müller-BBM (sub-project on storage facilities, 2009b), crude-oil-distillation capacity (in 2009, about 118 million t; MWV, 2010, p. 27) is used as the activity data for purposes of estimating emissions from storage in refineries.

The fugitive-VOC-emissions value specified in VDI Guideline 2440, 0.16 kg/t, may be used as the emission factor. For 2009, this leads to NMVOC emissions of 16,992 t and CH₄ emissions of 1,888 t.

Tank-storage facilities outside of refineries

According to Müller-BBM (sub-project on storage systems, 2009b), no emission factors can be derived, via evaluation of emissions declarations for storage systems, that would be representative of individual systems. This is due, so the same source, to the clearly widely differing emissions behaviour of different individual systems.

It was possible, however, to form aggregated emission factors. For each relevant group of data, this was done by correlating the sums of all emissions with the sums of all capacities.

For non-refinery tank-storage systems, storage of liquid petroleum products can be differentiated from storage of gaseous petroleum products, since the relevant data are suitably differentiated. (Müller-BBM, 2009a)

As a result, the following emission factors can be estimated:

	NMVOC	CH ₄	Units
Storage – liquid petroleum products	100	5	g/m ³
Storage – gaseous petroleum products	500	150	g/m ³

3.3.2.3.4.3 Uncertainties and time-series consistency (1.B.2.a.iv)

For the emissions data, the source-category uncertainties are given as 50 %. These figures are based on estimates of experts of the WEG, and of national experts, and from the research project FKZ 3707 42 103/01 of Müller-BBM from 2009.

3.3.2.3.4.4 Source-specific quality assurance / control and verification (1.B.2.a.iv)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For source category 1.B.2.a.iv (in the present case, with 1.B.2.a.ii, iii and v), a comparison with the IPCC default values (IPCC 1996b) shows good agreement. Table 1.62 (loc. cit.: p. 1.130) lists emission factors for this area in a sum ranging from 110 to 1,660 kg/PJ. Conversion of the German emission factor for 2008, 0.018 kg CH₄ / t crude oil, using the lower net calorific value of crude oil (42.7 MJ/kg), produces an emission factor of 467.5 kg/PJ. This value lies below the range for the default emission factor in the Reference Manual. Similarly, the emission factor listed by Austria for the year 2000, 0.033 kg/t crude oil, agrees well with the German emission factor determined on a country-specific basis. No further verification results are available at present.

According to Müller-BBM, the emission factors for NMVOC are confirmed – at least in terms of their order of magnitude – via results of independent analysis. For example, in the framework of a bottom-up analysis of a refinery tank-storage system, carried out by Müller-BBM, a value of 300 g/m³ was obtained, while a value of 200 g/m³ was obtained via measurements of middle-distillate tanks.

3.3.2.3.4.5 Source-specific recalculations (1.B.2.a.iv)

Recalculations were carried out in the area of CH₄ and NMVOC emissions to take account of the emissions from storage previously reported under 1.B.2.a.vi and of new findings from the research project in accordance with Müller-BBM (sub-project on storage facilities, 2009b).

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.3.4.6 Source-specific planned improvements (1.B.2.a.iv)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.5 Oil, distribution of oil products (1.B.2.a.v)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	-	CS	-	-	-	-	NO	NO	CS	NO
EF uncertainties in %		20								
Distribution of uncertainties		N								
EF-determination method										

The source category 1.B.2.a.v "Oil, distribution of oil products" is not a key source.

No decision tree is available for determining emissions from distribution (transport and transfer), nor is any relevant method prescribed (IPCC GPG 2000: Chapter 2 Energy). The only recourse in this case is to proceed by analogy to source category 1.B.2.a.iii.

3.3.2.3.5.1 Source category description (1.B.2.a.v)

Distribution

General information

Petroleum products are transported via ships, product pipelines, railway tank cars and road tankers, and they are transferred from tanks to other tanks. Germany's domestic sales of petroleum products totalled 109,590,000 t in 2009 (MWV, 2010, p. 51)). Domestic sales of petrol, pursuant to MWV (op. cit.), amounted to 20,233,000 t in 2009.

Tanker cars

About 13 million m³ of petrol fuels are transported annually in Germany via railway tank cars. Transfer/handling (filling/unloading) and tank losses result in emissions of only 1,260 t NMVOC and of 140 t CH₄ (total of 1,400 t VOC) per year (UBA, 2004b).

The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities.

Cleaning of transport vehicles

Tank interiors are cleaned prior to tank repairs, prior to safety inspections, in connection with product changes and in connection with lease changes.

The inventory currently covers cleaning of railway tank cars. The residual amounts remaining in railway tank cars' tanks after the tanks have been emptied – normally, between 0 and 30 litres (up to several hundred litres in exceptional cases) – are not normally able to evaporate completely. They thus produce emissions when the insides of tanks are cleaned.

Each year, some 2,500 cleaning operations are carried out on railway tank cars that transport petrol. The emissions released, via exhaust air, in connection with cleaning of tank cars' interiors amount to about 36,000 kg NMVOC and 4,000 kg CH₄ per year (a total of 40,000 kg/a VOC) (UBA 2004b, p.34).

On the whole, oil consumption is expected to stagnate or decrease. As a result, numbers of oil storage facilities can be expected to decrease as well. In light of these trends, a long-term increase in the average transport distance for petroleum products – currently 200 km (loc. cit.) – can be expected.

Any additional measures for prevention and reduction measures could affect emissions in this source category only slightly. At the same time, emissions can be somewhat further reduced from their current levels via a combination of various technical and organizational measures. Emissions during handling – for example, during transfer to railway tank cars – are produced especially by residual amounts of petrol that remain after tanks have been emptied. Such left-over quantities in tanks can release emissions via manholes the next time the tanks are filled. Study is thus underway to determine the extent to which "best practice" is being followed at all handling stations, and whether this extent has to be taken into account in emissions determination. In addition, improvements of fill nozzles enhance efficiency in prevention of VOC emissions during fuelling.

Petrol stations

Germany currently has 14,785 petrol stations (MWV 2010). In 2009, the stations sold some 20.2 million t of petrol.

Table 70: Activity data for calculation of emissions in 1.B.2.a.v

Activity data	1990	2009	Change
Number of petrol stations	19,317	14,785	-23 %
Petrol distribution	31,257 kt	20,233 kt	-35 %

Significant quantities of fugitive VOC emissions are released into the environment during transfers from tanker vehicles to storage facilities and during refuelling of vehicles. The applicable regulations for petrol stations, under immissions-control law, for limiting such emissions are set forth in two Ordinances for Execution of the Federal Immissions Control Act (BImSchV) that were issued in 1992 and 1993. The ordinances cover the areas of

transfers and storage of petrol (20th BImSchV) and refuelling of vehicles, with petrol, at petrol stations (21st BImSchV).

Table 71: Emission factors for petrol fuels during refuelling and transfer/storage

Emission factor (2009)	CH ₄	NMVOC
Refuelling	0.2053 kg/t	1.848 kg/t
Transfer/storage of petrol fuels	0.52 kg/t	4.68 kg/t

Successful use of required emissions-control equipment, such as gas-balancing (20th BImSchV) and gas-recovery (21st BImSchV) systems, along with use of automatic monitoring systems (via the amendment of the 21st BImSchV of 6 May 2002), have brought about a continual decrease in VOC emissions.

In the main, the emissions are fugitive emissions that occur in transfers (filling/unloading) and as losses from containers (tank breathing losses). In the area regulated by the 20th BImSchV, such emissions have decreased from about 86,000 tonnes (1993) to about 7,000 tonnes (2009), and in the area regulated by the 21st BImSchV, they have dropped from nearly 60,000 tonnes (1993) to about 10,000 tonnes (2009).

3.3.2.3.5.2 Methodological issues (1.B.2.a.v)

Distribution

Currently, the inventory covers emissions relative to distribution of one petroleum product (petrol).

The IPCC Synthesis and Assessment Report Part I (IPCC, 2004) noted that the IEF of the source category *Refining / storage* is the lowest among those of Annex I countries. The low IEF for this source category is due to implementation of technical requirements from national legal provisions relative to equipping of systems for storage, transfer and transport of volatile petroleum products. The *Technical Instructions on Air Quality Control* (TA Luft, 2002) require the use of structurally tight valves, flanged joints and connections, pumps and compressors, as well as storage of petroleum products in fixed-roof tanks with connections to gas-collection lines.

The calculation procedures use country-specific emission factors and activity data for NMVOC and methane emissions.

The CH₄ emission factor, 0.105 kg/t, and the NMVOC emission factor, 1.050 kg/t, were derived from a VOC emission factor (the CH₄ emission factor is equivalent to 10 % of the emission factor for VOC) and have been continually updated in keeping with improvements in emissions control technology.

Cleaning

Pursuant to the UBA text (2004b), a total of 1/3 of all relevant transports are carried out with railway tank cars. The remaining 2/3 of all transports are carried out with other means – primarily with road tankers.

The 1/3 to 2/3 relationship given by the report is assumed to be also applicable to the emissions occurring in connection with cleaning. Currently, the inventory includes 36,000 kg of NMVOC emissions from cleaning of railway tank cars. Emissions from cleaning of other

transport equipment – primarily road tankers – are derived from that figure; they amount to about 70,000 kg NMVOC.

More thorough emissions collection upon opening of manholes of railway tank cars (a volume of about 14.6 m³ escapes), along with more thorough treatment of exhaust from cleaning of tanks' interiors, could further reduce VOC emissions. Exhaust cleansing is assumed to be carried out via one-stage active-charcoal adsorption. For an initial load of 1 kg/m³, exhaust concentration levels can be reduced by 99.5 %, to less than 5 g/m³. As a result, the remaining emissions amount to only 1.1 t. This is equivalent to a reduction of about 97 % (UBA, 2004b, p. 34) from the determined level of 36.5 t/a (without adsorption).

3.3.2.3.5.3 *Uncertainties and time-series consistency (1.B.2.a.v)*

For the emissions data, the source-category uncertainties are given as 20 %. These figures are based on estimates of WEG experts and national experts, and they lie within the range listed for a number of relevant default emission factors (IPCC GPG 2000; Chapter 2.7.1.6.).

3.3.2.3.5.4 *Source-specific quality assurance / control and verification (1.B.2.a.v)*

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

NMVOC emissions from filling, within refineries, of vehicles for road, railway and waterway transports (EMEP/CORINAIR Emission Inventory Guidebook – 2005 SNAP 050501) account for an average of 0.2 % of all NMVOC emissions throughout Europe. Emissions from the actual relevant transport processes, and from fuel storage outside of refineries (but not in petrol stations), account for an additional 0.9 % of such emissions (SNAP 050502). Emissions from fuel storage in the area of petrol stations account for 2.3 % of such emissions. The listed emission factors are 200-500 g/t of transferred petrol for SNAP 050501, 600-3120 g/t for SNAP 050502 and 2000-4500 g/t for SNAP 050503. No further verification results are available at present.

3.3.2.3.5.5 *Source-specific recalculations (1.B.2.a.v)*

The use of more-specific emission factors for CH₄ and NMVOC in the area of handling of petrol fuels at petrol stations has created a need for recalculations. An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.3.5.6 *Source-specific planned improvements (1.B.2.a.v)*

A research project will be carried out to update data for cleaning of railway tank cars (UBA 2004b) and to obtain data for other cleaning areas, such as cleaning of ships and road tankers.

3.3.2.3.6 *Oil, other (1.B.2.a.vi)*

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	-	IE	-	-	-	-	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category 1.B.2.a.vi "Oil, other" is not a key source.

3.3.2.3.6.1 Source category description (1.B.2.a.vi)

No decision tree or other guidelines for determining distribution emissions are available. Pursuant to the reporting guidelines of the EMEP Emission Inventory Guidebook, no instructions relative to other emissions are available.

3.3.2.3.6.2 Methodological issues (1.B.2.a.vi)

No results are available for this source category.

3.3.2.3.6.3 Uncertainties and time-series consistency (1.B.2.a.vi)

No information relative to uncertainties and time-series consistency is required.

3.3.2.3.6.4 Source-specific quality assurance / control and verification (1.B.2.a.vi)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.3.6.5 Source-specific recalculations (1.B.2.a.vi)

No recalculations are required.

3.3.2.3.6.6 Source-specific planned improvements (1.B.2.a.vi)

No improvements are planned at present.

3.3.2.4 Natural gas (1.B.2.b)

CRF 1.B.2.b					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
Natural Gas	I / t / T2	CH ₄	0.56 %	0.74 %	+1.9 %

The source category 1.B.2.b "Natural gas" is a key source of CH₄ emissions in terms of emissions level and trend.

3.3.2.4.1 Natural gas, exploration (1.B.2.b.i)

Schadstoff	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	IE	IE	-	-	-	-	NO	NO	IE	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category 1.B.2.b.i "Natural gas, exploration" is a key source of CH₄, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

3.3.2.4.1.1 Source category description (1.B.2.b.i)

Source category 1.B.2.b.i is considered together with source category 1.B.2.a.i (Oil, exploration). Consequently, the aggregated, non-subdivided data of 1.B.2.b.i are included in source category 1.B.2.a.i.

3.3.2.4.1.2 Methodological issues (1.B.2.b.i)

The approach used in the calculation procedures is equivalent to that used for source category 1.B.2.a.i.

3.3.2.4.1.3 Uncertainties and time-series consistency (1.B.2.b.i)

See 1.B.2.a.i for explanations of uncertainties and time-series consistency.

3.3.2.4.1.4 Source-specific quality assurance / control and verification (1.B.2.b.i)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

See 1.B.2.a.i for an explanation of source-specific quality assurance / control and verification.

3.3.2.4.1.5 Source-specific recalculations (1.B.2.b.i)

No recalculations are required.

3.3.2.4.1.6 Source-specific planned improvements (1.B.2.b.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.2 Natural gas, production and processing (1.B.2.b.ii)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	-	-	-	-	NO	CS	CS	CS
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
EF-determination method	CS	CS								

The source category 1.B.2.b.ii "Natural gas, production and processing" is a key source of CH₄, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

Emissions were determined using the methods set forth in IPCC GPG (2000: Figure 2.12 Decision Tree for Natural Gas Systems, page 2.80; here, "Box 4", and "Box 3" where applicable).

3.3.2.4.2.1 Source category description (1.B.2.b.ii)

The emissions of this source category consist of emissions from the activities of extraction, pretreatment and processing. In 2009, a total of 14.5 billion m³ of natural gas were extracted in Germany (WEG 2010, p. 44, natural gas extraction). Of that quantity, 40 % was acid gas. In Germany, pretreatment is carried out in near-wellhead systems directly at gas fields. Emissions can be produced by various types of plants, throughout a spectrum ranging from pretreatment to completion of processing.

Pretreatment systems (processing)

After being brought up from underground reserves, natural gas is first treated in drying plants. Such plants separate out associated water from reserves, liquid hydrocarbons and

various solids. Glycol is then used to remove the water vapour remaining in the gas (WEG 2008a²⁹, p. 25).

Acid gas

The natural gas drawn from Germany's Zechstein geological formation contains hydrogen sulphide. In this original state, the gas, known as "acid gas", has to be subjected to special treatment. Such gas is transported via separate, specially protected pipelines (due the hazardousness of hydrogen sulphide) to central processing plants that wash out its hydrogen sulphide via chemical and physical processes.

The natural gas that leaves these processing plants is ready for use. The hydrogen sulphide is converted into elementary sulphur and is used primarily by the chemical industry, as a basic raw material. Sulphur production from natural gas production in Germany amounted to about 927,353 million tonnes in 2009 (WEG, 2010, p. 51).

3.3.2.4.2.2 Methodological issues (1.B.2.b.ii)

Natural gas

The specific emission factors were derived by the Federal Environment Agency, on the basis of research in the literature (SCHÖN, WALZ et al., 1993) and queries to relevant companies, and they have been continually used.

An emission factor of 62 kg/TJ is used for determining methane emissions in natural-gas processing systems. The IPCC Guidelines (1996b) give a default value for the emission factor of 58 to 111 kg/TJ (cf. also SCHNEIDER-FRESENIUS et al., 1989); that value applies for the entire source category, however. A comparison with the summed German emission factors converted using the lower net calorific value of natural gas (31.7 MJ/Nm³) shows good agreement. The country-specific determination produced an overall emission factor that lies within the lower range of the spread for the IPCC default value.

For purposes of determination of CO₂ and CH₄ emissions from natural gas extraction, the relevant default emission factors are used: 2.6 kg/m³ for CH₄ and 0.095 kg/m³ for CO₂.

The emission factors given by the Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association (WEG) (cf. NIR 2009: Chapter 3.2.2.3.2., Table 42) seem unsuited, because they cover the relevant complete processes (energy production, extraction, etc.).

Acid gas

For calculation of CO₂ and CH₄ emissions from acid-gas processing, a split factor of 0.4 is applied to the activity data (total natural gas extraction = 14.5 billion m³). These figures are based on the WEG report on acid-gas processing (WEG, 2008b).

The CO₂ emission factor used for acid-gas processing, 0.23 t / 1,000 m³, has been obtained by averaging emission factors from Austria.

²⁹ WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 p.

3.3.2.4.2.3 Uncertainties and time-series consistency (1.B.2.b.ii)

For the emissions data, the source-category uncertainties are given as 20 %. These figures are based on estimates of WEG experts and national experts, and they lie within the range listed for a number of relevant default emission factors (IPCC GPG 2000; Chapter 2.7.1.6.).

3.3.2.4.2.4 Source-specific quality assurance / control and verification (1.B.2.b.ii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of quality assurance were taken into account in determination and documentation of emissions.

3.3.2.4.2.5 Source-specific recalculations (1.B.2.b.ii)

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.4.2.6 Source-specific planned improvements (1.B.2.b.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.3 Gas, transmission (1.B.2.b.iii)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	-	CS	-	-	-	-	NO	CS	NO	NO
EF uncertainties in %		20								
Distribution of uncertainties		N								
EF-determination method		CS								

The source category 1.B.2.b.iii "Natural gas, transmission" is a key source of CH₄, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

Emissions were determined using the methods set forth in IPCC GPG (2000: Figure 2.12 Decision Tree for Natural Gas Systems, page 2.80; here, "Box 4", and "Box 3" where applicable).

3.3.2.4.3.1 Source category description (1.B.2.b.iii)

This source category's emissions consist of emissions from activities of gas producers and suppliers. In Germany, natural gases (natural gas and oil gas) are transported from production and processing companies/plants to gas suppliers and other processors. In practice, such transports take place via both pipelines (high-pressure pipelines) and containers (tanks). Until 1997, significant amounts of city gas were transported via pipelines.

Gas is moved via high-pressure pipelines (with pressure exceeding 1 bar) made of special plastics and steel / ductile-cast iron parts.

Some of the natural gas is stored in underground reservoirs to permit, and guard against, interruptions of pipeline transports.

Gas is also transported in tanks, via tanker ships, on inland waterways.

3.3.2.4.3.2 Methodological issues (1.B.2.b.iii)

Pipelines (high-pressure pipelines)

Some of the gas extracted in Germany is moved via pipelines from gas fields and their pumping stations (either on land or offshore). The companies that operate the most important long-distance gas pipelines in Germany are organised within the *Wirtschaftsverband Erdöl- und Erdgasgewinnung* association of oil and gas producers (WEG; pipelines from pump stations to gas suppliers) and in the *Federal Association of the German Gas and Water Industry* (BGW; pipelines from gas suppliers to end customers).

Containers (tanks), and their transport via inland-waterway tanker ships, road tankers and railway tank cars

In Germany, natural gas is first transported in tanks, via tanker ships on inland waterways, to storage reservoirs and to processing companies, before then being transported to customers via pipelines or in tanks (cf. source category 1.B.2.b.iv). No tank transports take place via road tankers on roads or railway tank cars; the amounts in question normally preclude such transports (cf. source category 1.B.2.b.iv, Chapter 3.3.2.4.4).

Storage reservoirs

Both natural and man-made underground storage reservoirs are used for safe storage of large amounts of natural gas. Germany has some 40 underground storage reservoirs. Many of these storage reservoirs are located in depleted oil and natural-gas fields. In such fields, the natural cavities in porous rock provide the storage capacity. Depending on the size of the geological structures concerned, porous-rock reservoirs can hold between 100 million m³ and several billions of m³ of gas. About half of the stored gas is used for purposes of load balancing. It is referred to as *working gas*. The remaining gas, known as *cushion gas*, functions as a pressure buffer and keeps water in the reservoir from seeping into wellholes. Cavern reservoirs consist of caverns that have formed in underground salt formations via leaching processes. An average-sized cavern can hold about 30 million m³ of usable gas. In addition, it will hold a gas cushion ranging from 10 million m³ to 30 million m³ in size. As of the beginning of 2000, Germany's underground gas-storage reservoirs had a working-gas volume of over 16 billion m³. Further expansions are currently in progress (cf. WEG, 2000: p. 18).

3.3.2.4.3.3 Uncertainties and time-series consistency (1.B.2.b.iii)

See 1.B.2. for explanations of uncertainties and time-series consistency.

3.3.2.4.3.4 Source-specific quality assurance / control and verification (1.B.2.b.iii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.4.3.5 Source-specific recalculations (1.B.2.b.iii)

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.4.3.6 Source-specific planned improvements (1.B.2.b.iii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.4 Gas, distribution (1.B.2.b.iv)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	-	CS	-	-	-	-	NO	CS	NO	NO
EF uncertainties in %		20								
Distribution of uncertainties		N								
EF-determination method		CS								

The source category 1.B.2.b.iv "Natural gas, distribution" is a key source of CH₄, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

3.3.2.4.4.1 Source category description (1.B.2.b.iv)

This source category's emissions consist of emissions from activities of companies that supply gas to customers. In Germany, natural gas is distributed to users primarily via pipeline networks. Gas is distributed via low-pressure pipelines (with pressure up to 100 mbar) and medium-pressure pipelines (with pressure between 100 mbar and 1 bar), made of special plastics, steel / ductile-cast iron and grey cast iron. To prevent double-counting, the entire high-pressure pipeline network of companies involved in gas production and long-distance gas transports has been combined within 1.B.2.b.iii.

Emissions caused by gas distribution have decreased by some 4 %, even though gas throughput has increased considerably and the distribution network has been enlarged by over 80 % with respect to its size in 1990. One important reason for this improvement is that the gas-distribution network has been modernised, especially in eastern Germany. In particular, the share of grey cast iron lines in the low-pressure network has been reduced, with such lines being supplanted by low-emissions plastic pipelines. Another reason for the reduction is that fugitive losses in distribution have been reduced through a range of technical improvements (tightly sealing fittings such as flanges, valves, pumps, compressors) undertaken in keeping with emissions-control provisions in relevant regulations (TA Luft 1986 and 2002; VDI-Richtlinie (VDI Guideline) 2440). The main framework data relative to such measures are summarised in the following table.

Table 72: The gas-distribution network (1.B.2.b.iii and 1.B.2.b.iv) and the methane emissions it causes

Parameter	1990	1995	2000	2005	2009
Total length of pipeline network [km]	245,852	320,878	369,390	411,954	447,039
Total methane emissions [t]	199,567	204,309	192,281	190,904	191,620
Implied emission factor [kg/km]	811.7	636.7	520.5	463.4	428.6
Change in the emission factor with respect to the base year	0 %	22 %	36 %	43 %	47 %

Some of the natural gas is stored in above-ground reservoirs (spherical tanks) to permit, and guard against, interruptions of pipeline transports. Tanks filled with gas, for distribution and transport, are transported via tanker ships (on inland waterways), railway tank cars and tanker trucks.

Gas is also sold in special containers (small tanks, flasks). Such containers are transported as unit loads, usually in larger packages, bunches or containers.

Distribution via pipelines

Relevant calculations are carried out on the basis of available network statistics on the composition of distribution networks in the low-pressure and medium-pressure sectors. In the early 1990s, emissions from distribution of city gas were also taken into account in calculations. In 1990, the city-gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast iron lines and 84 % consisted of steel and ductile cast iron lines. The following table provides an overview of trends in the way the network is structured. The table includes an overview of distribution networks for city gas. A particularly noticeable development is that the plastic pipeline network in the medium-pressure sector has been expanded by 400 %.

Table 73: Structure of the gas-distribution network

Gas-distribution network		Length of the distribution network		
Pressure level	Material	1990 [km]	2009 [km]	Change [%]
Low pressure	Grey cast iron	17,260	1,214	-93
	Plastic	23,894	41,731	+74
	Steel and ductile cast iron	119,761	162,445	+36
Medium pressure	Plastic	43,307	174,182	+402
	Steel and ductile cast iron	41,622	67,468	+62
Total		245,844	447,039	+81

General information relative to fulfillment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. Chapter 3.3.2).

3.3.2.4.4.2 Methodological issues (1.B.2.b.iv)

Distribution via containers

Gas in containers (small tanks, flasks) is distributed via filling plants. Filled tanks are transported via inland ships, railway tank cars and road tankers. Gas in containers (flasks) is also transported by customers, prior to being used (it is not transported on a unit-load basis, however). To a small extent, gas consumers also store gas temporarily before using it (cf. the consumption information, for the various source categories, provided under 1.A).

Storage reservoirs

Medium quantities of gas are stored in man-made above-ground reservoirs. Germany uses spherical tanks for this purpose.

3.3.2.4.4.3 Uncertainties and time-series consistency (1.B.2.b.iv)

See 1.B.2. for explanations of uncertainties and time-series consistency.

3.3.2.4.4.4 Source-specific quality assurance / control and verification (1.B.2.b.iv)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.4.4.5 Source-specific recalculations (1.B.2.b.iv)

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.4.4.6 Source-specific planned improvements (1.B.2.b.iv)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.5 Gas, other leaks (1.B.2.b.v)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	-	CS	-	-	-	-	NO	CS	NO	NO
EF uncertainties in %		20								
Distribution of uncertainties		N								
EF-determination method										

The source category 1.B.2.b.v "Natural gas, other leaks" is a key source of CH₄, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

No decision tree or other guidelines are available for determination of emissions from distribution (cf. IPCC GPG 2000: Chapter 2 Energy).

Pursuant to the reporting guidelines of the EMEP Emission Inventory Guidebook, no instructions relative to "other" emissions are available (EMEP 2005a: Group 5: Extraction & distribution of fossil fuels and geothermal energy).

CO₂ emissions are not determined, even though the CRF-Reporter software and the CRF list that gas, since the Guidelines do not list that gas for this source category.

3.3.2.4.5.1 Source category description (1.B.2.b.v)

The source category describes emissions from leakage in the industrial sector and in the areas of private households and commerce/trade/services.

No city gas has been fed into the grid in Germany since 1997.

3.3.2.4.5.2 Methodological issues (1.B.2.b.v)

The activity data are based on results of work carried out by the Working Group on Energy Balances (AGEB). The emission factors are country-specific.

3.3.2.4.5.3 Uncertainties and time-series consistency (1.B.2.b.v)

For the emissions data, the source-category uncertainties are given as 20 %. That figure is based on estimates of WEG experts and national experts, and it lies within the range listed for a number of relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.5.4 Source-specific quality assurance / control and verification (1.B.2.b.v)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.4.5.5 Source-specific recalculations (1.B.2.b.v)

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.4.5.6 Source-specific planned improvements (1.B.2.b.v)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.6 Venting and flaring (1.B.2.c)

CRF 1.B.2.c.i				
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
- / -				

The source category 1.B.2.c "Venting and flaring" is not a key source.

The source categories in the overarching group of fugitive emissions from 1.B.2.c "Venting and flaring" cover greenhouse-gas and pollutant emissions either vented and flared directly into the atmosphere.

3.3.2.4.7 Venting and flaring, oil (1.B.2.c.i)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	CS	-	-	-	D	D	D	CS	D
EF uncertainties in %						25				
Distribution of uncertainties						N				
EF-determination method										

The source category 1.B.2.c.i "Venting and flaring, oil" is not a key source.

No methods for determining the relevant emissions have been prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.a.iii) includes venting and flaring as a criterion.

3.3.2.4.7.1 Source category description (1.B.2.c.i)

Pursuant to general requirements of the Technical Instructions on Air Quality Control (TA Luft; 2002), gases, steam, hydrogen and hydrogen sulphide released from pressure valves and venting equipment must be collected in a gas-collection system. Wherever possible, gases so collected are burned in process combustion. Where such use is not possible, the gases are piped to a flare. Flares used for flaring of such gases must fulfill at least the requirements for flares for combustion of gases from operational disruptions and from safety valves. For refineries and other types of plants in source categories 1.B.2, flares are indispensable safety components. In crude-oil refining, excessive pressures can build up in process systems, for various reasons. Such excessive pressures have to be reduced via safety valves, to prevent tanks and pipelines from bursting. Safety valves release relevant products into pipelines that lead to flares. Flares carry out controlled burning of gases released via excessive pressures. When in place, flare-gas recovery systems liquify the majority of such gases and return them to refining processes or to refinery combustion systems. In the process, 99 % of hydrocarbons are converted to CO₂ and H₂O. When a plant has such systems in operation, therefore, its flarehead will seldom show more than a small pilot flame.

3.3.2.4.7.2 Methodological issues (1.B.2.c.i)

The source category's emissions are determined on the basis of the research report "Status of and trends in greenhouse-gas emissions in upstream processes for oil and natural gas" ("Stand und Entwicklung von Treibhausgasemissionen in den Vorketten für Erdöl und Erdgas"; ÖKO-INSTITUT e.V. 2006a). The emissions include flaring losses of onshore installations. Venting emissions are taken into account in 1.B.2.a.iv. In addition, flaring emissions in refineries are determined with emission factors developed by experts.

The results of quality assurance are taken into account in determination and documentation of emissions.

3.3.2.4.7.3 Uncertainties and time-series consistency (1.B.2.c.i)

For the emissions data, the source-category uncertainties are given as 20 to 25 %. Those figures are based on estimates of national experts, and they lie within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.7.4 Source-specific quality assurance / control and verification (1.B.2.c.i)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

See 1.B.2 for an explanation of source-specific quality assurance / control and verification.

3.3.2.4.7.5 Source-specific recalculations (1.B.2.c.i)

Recalculations were carried out for carbon dioxide, NMVOC and methane, to take account of available new emission factors for flaring in refineries. In keeping with remarks made by the Expert Review Team (ERT) during the in-country review 2010, recalculations were carried out for nitrous oxide emissions, using the emission factor from the IPCC Good Practice Guidance 2000 (Table 2.16) (cf. Chapter 10.5.2.2).

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.4.7.6 Source-specific planned improvements (1.B.2.c.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.8 Venting and flaring, gas (1.B.2.c.ii)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	Data	D	-	-	-	D	-	-	CS	D
EF uncertainties in %	25	25				25				
Distribution of uncertainties	N	N				N				
EF-determination method										

Pursuant to the classification of the aggregated source category 1.B.2.c "Venting and flaring", the source category 1.B.2.c.ii "Venting and flaring, gas" is not a key source.

No methods for determining the relevant emissions have been prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.a.iv) includes venting and flaring as a criterion.

3.3.2.4.8.1 Source category description (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

3.3.2.4.8.2 Methodological issues (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

The SO₂ emissions are obtained from the activity data of 14,679,000 m³ of flared natural gas (WEG 2010, p. 49) and an emission factor of 0.140 kg / 1,000 m³, a factor which takes account of an average H₂S content of 5 volume percent.

Emissions of CO, CO₂, CH₄ and NMVOC have been determined with the default factors from IPCC-GPG (2000) and the "EMEP/EEA air pollutant emission inventory guidebook — 2009".

Venting emissions are taken into account in source category 1.B.2.b.iii.

3.3.2.4.8.3 Uncertainties and time-series consistency (1.B.2.c.ii)

For the emissions data, the source-category uncertainties are given as 25 %. That figure is based on estimates of national experts, and it lies within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.8.4 Source-specific quality assurance / control and verification (1.B.2.c.ii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of quality control were taken into account in determination and documentation of emissions.

See 1.B.2 for an explanation of source-specific quality assurance / control and verification.

3.3.2.4.8.5 Source-specific recalculations (1.B.2.c.ii)

As a result of remarks made by the Expert Review Team (ERT) during the in-country review 2010, nitrous oxide emissions were recalculated with emission factors from the Good Practice Guidance 2000 (Tabelle 2.16) for flaring in gas production and in gas processing.

3.3.2.4.8.6 Source-specific planned improvements (1.B.2.c.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.5 Geothermal energy (1.B.2.d)

3.3.2.5.1 Source category description (1.B.2.d)

The source category 1.B.2.d "Geothermal energy" is not a key source.

Geothermal energy is a renewable form of energy. Geothermal energy systems that tap geothermal heat to a depth of 400 metres are classified as "near-surface" geothermal energy systems. Near-surface geothermal systems generate heating and cooling energy by means of heat pumps. They are also used for heating service water. Geothermal energy systems that tap geothermal heat at depths greater than 400 metres are classified as "deep" geothermal energy systems. Geothermal heating stations use the heat in their thermal-water flows directly, and provide heating and cooling to end consumers, via district / local heating

and cooling networks. Geothermal power stations convert the heat in their thermal-water flows into electricity. In most cases, they produce heat as well, via processes for combined heat/power (CHP) production.

In 2009, a total of four geothermal energy power stations produced electricity in Germany:

- A power station in Landau (RLP); electricity production since fall 2007,
- A thermal power station in Unterhaching (BAY); test operations with electricity production in June and July 2009,
- A thermal power station in Bruchsal (BW); entered service with electricity production in December 2009,
- A thermal power station in Neustadt-Glewe; electricity production since 2004.

Numerous new thermal power stations are being planned or built.

Operation of geothermal power stations and heat stations in Germany produces no emissions of climate-relevant gases. The thermal-water circuits of such installations are closed and airtight, both above and below ground level. As a result, no emissions occur during their operation. What is more, releases of the gases dissolved in their heat-carrying fluids – primarily H₂, CH₄, CO₂ and H₂S – would not produce concentrations that would require reporting (cf. "Environmental effects of geothermal power generation; analysis and assessment of small-scale and large-scale environmental impacts of geothermal power generation" ("Umwelteffekte einer geothermischen Stromerzeugung, Analyse und Bewertung der klein- und großräumigen Umwelteffekte einer geothermischen Stromerzeugung"), FKZ 205 42 110, Chapter A.2.3.5). For this reason, the emissions are reported as "NO". In 2009, all geothermal energy systems met their own power requirements (primarily power for operating pumps) by drawing electricity from the grid. In the report, that use is included in the relevant source categories.

3.3.2.5.2 *Methodological issues (1.B.2.d)*

The IPCC Reference Manual does not describe any methods for source category 1.B.2.d "Other" (IPCC, 1996b: p. 1.132f).

No emission factors for greenhouse gases and pollutants that could escape in connection with drilling for tapping of geothermal energy (both near-surface and deep energy) are known for Germany at present. As is known from oil and gas exploration, however, it is clear that virtually any drilling will lead to releases of gases bound in underground layers – and the gases involved can include H₂, CH₄, CO₂, H₂S and Rn (cf. "Environmental effects of geothermal electricity production; analysis and assessment of the small-scale and large-scale environmental effects of geothermal electricity production", FKZ 205 42 110, Chapter A.2.1.5). Drilling to tap near-surface geothermal energy can be expected to produce only very slight emissions. In all drilling to tap deep geothermal energy, "blow-out preventers" are used to prevent gas releases. In addition, drilling fluids are used to drive any gases released into boreholes back into the rock layers traversed in drilling.

3.3.2.5.3 *Uncertainties and time-series consistency (1.B.2.d)*

No explanations of uncertainties and time-series consistency are required.

3.3.2.5.4 *Source-specific quality assurance / control und –Verifizierung (1.B.2.d)*

No explanations relative to source-specific quality assurance / control and verification are required. Verification is not possible at present.

3.3.2.5.5 *Source-specific recalculations (1.B.2.d)*

No recalculations are required.

3.3.2.5.6 *Planned improvements (1.B.2.d)*

Even though the quantities involved are expected to be very small, plans call for quantification of gas releases from exploratory drilling in cases in which no blow-out preventers are used (in the near-surface range to depths of 400 m).

4 INDUSTRIAL PROCESSES (CRF SECTOR 2)

4.1 Overview (CRF Sector 2)

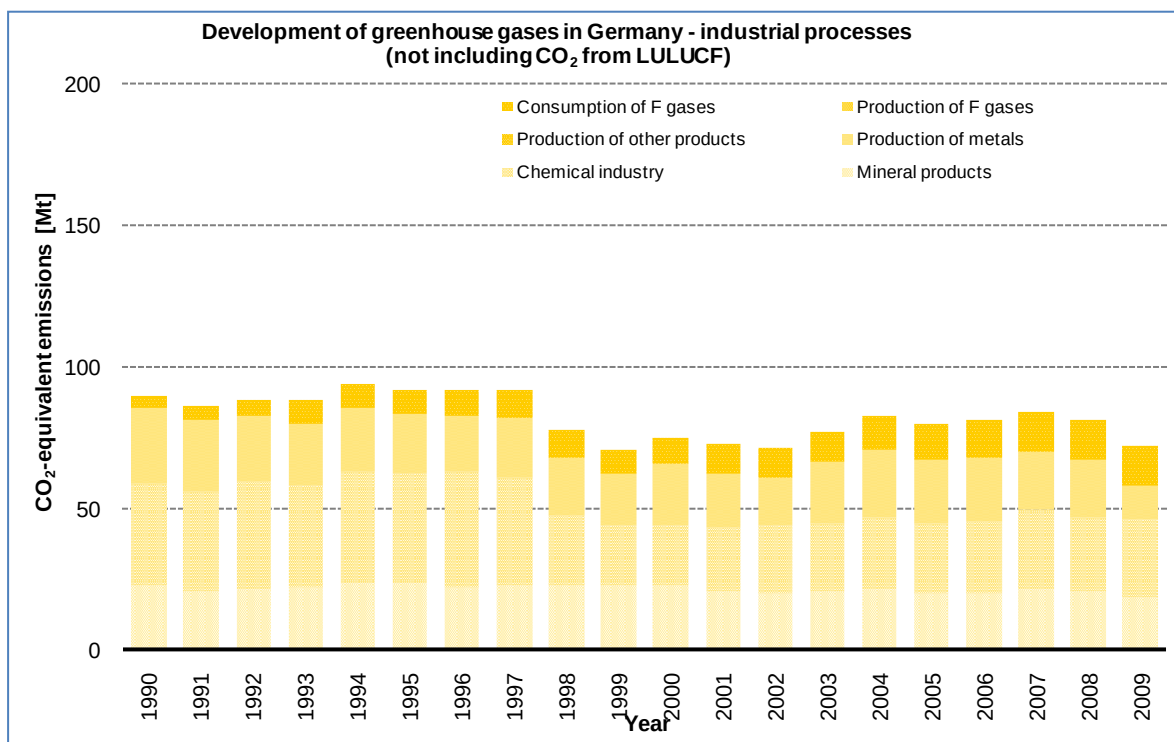


Figure 40: Overview of greenhouse-gas emissions in CRF Sector 2

4.2 Mineral products (2.A)

Source category 2.A Mineral products is divided into sub- source categories 2.A.1 through 2.A.7. These include:

- Cement production (2.A.1),
- Lime burning (2.A.2),
- Limestone and dolomite use (2.A.3),
- Soda ash production (2.A.4),
- Bitumen roofing (2.A.5),
- Road paving with asphalt (2.A.6), and
- in Other (2.A.7), glass production and ceramics production.

4.2.1 Mineral products: cement (2.A.1)

4.2.1.1 Source category description (2.A.1)

CRF 2.A.1											
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions				2009 – contribution to total emissions			Trend	
Cement production		l / t	CO ₂	1.24 %				1.31 %			-18.7 %
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂	
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	NO	CS	CS	
EF uncertainties in %	± 2	--	--	--	--	--					
Distribution of uncertainties	N	--	--	--	--	--					
EF-determination method	CS	--	--	--	--	--					

The source category “*Cement production*” is a key source for CO₂ emissions in terms of both emissions level and trend.

The remarks below refer only to production of cement clinkers, because clinker grinding is not relevant as a dust source in the present context.

The clinker-burning process emits climate-relevant gases. CO₂ accounts for the great majority of these emissions. The CO₂ emissions from pertinent raw materials are tied directly to the quantities of cement clinkers that are produced. Pursuant to the German Cement Works Association (VDZ, 2010) clinker production in 2009 amounted to 23,232 kt³⁰. Raw-material-related CO₂ emissions are calculated with a country-specific emission factor, as determined by the *German Cement Works Association* (VDZ) from plant-specific data, of 0.53 t CO₂/t cement clinkers. Clinker production produced raw-material-related CO₂ emissions of 12,313 kt CO₂ in 2009.

³⁰ Provisional value (rounded off).

Table 74: Production and CO₂ emissions in the German cement industry

Year	Clinker production	Emission factor	Raw-material-related CO ₂ emissions	Cement production (from German clinkers)
	[kt/a]	[t CO ₂ /t]	[kt/a]	(kt/a)
1990	28,577	0.53	15,146	37,772,000
1991	25,670		13,605	34,341,000
1992	26,983		14,301	37,331,000
1993	27,146		14,387	36,649,000
1994	28,658		15,189	40,512,000
1995	29,072		15,408	35,862,276
1996	27,669		14,664	34,318,315
1997	28,535		15,124	34,147,612
1998	29,039		15,391	35,601,157
1999	29,462		15,615	37,438,106
2000	28,494		15,102	35,413,823
2001	25,227		13,370	32,117,712
2002	23,954		12,696	31,009,278
2003	25,233		13,373	32,749,441
2004	26,281		13,929	31,853,656
2005	24,379		12,921	31,009,226
2006	24,921		13,208	33,629,885
2007	26,992		14,306	33,382,323
2008	25,366		13,444	33,581,301
2009	23,232		12,313	30,441,010

Source: BdZ 1995 (until 1994); VDZ, 2010 (as of 1995)

4.2.1.2 Methodological issues (2.A.1)

Activity data

Activity data are determined via summation of figures for individual plants (until 1994, activity data were determined on the basis of data of the BDZ). As of 1995, following optimisation of data collection within the association, activity data were compiled by the VDZ, and by its cement-industry research institute (located in Düsseldorf), via surveys of German cement works and use of BDZ figures. In the main, the data consists of data published in the framework of CO₂ monitoring, supplemented with data for plants that are not BDZ members (in part, also VDZ estimates).

In Table 74 summarises the activity data for cement clinkers and cement, and the raw-material-related CO₂ emissions as determined from clinker production, for the years 1990 through 2009.

Emission factors

The emission factor used for emissions calculation, 0.53 t CO₂ / t cement clinkers, is based on mass-weighted figures for individual plants, i.e. the VDZ determined the emission factor by aggregating plant-specific data relative to fractions of CaO and other metal oxides (MgO; in raw materials, and containing carbonate) in clinkers. The emission factor was confirmed in the framework of a research project (cf. also 4.2.1.6).

In the German cement industry, dust separated from exhaust gas is returned to the burning process. As a result, carbonate release from clinker raw materials can be determined directly from clinkers' metal-oxide content, without any need to take account of significant losses via the exhaust-gas pathway.

The emission factor of 0.53 t CO₂ / t cement clinkers was applied to the entire time series.

Raw-material-related CO₂ emissions in the cement industry are determined, in accordance with the *IPCC-GPG*, via the following equation:

$$\text{CO}_2 \text{ emissions} = \text{emission factor (EF}_{\text{clinkers}}) \times \text{clinker production}$$

(Table 74 shows calculated CO₂ emissions for the German cement industry for the years covered by the report.)

4.2.1.3 Uncertainties and time-series consistency (2.A.1)

For the activity data, time-series consistency is assured by the long period of time over which the association has collected pertinent data; for the emission factor, it is assured via use of a standard approach for all relevant years. Cf. also Chapter 4.2.1.6.

The listed uncertainties were determined via experts' assessment pursuant to Tier 1 of the IPCC GPG rules (2000: Chapter 6.3 p. 6.12).

Most companies are required to report clinker-production data within the framework of CO₂-emissions trading. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5 %. The uncertainties for the activity data used were thus estimated as -2.5 % and +2.5 %.

The uncertainty for the emission factor used was estimated as +/- 2 %. This was confirmed via the surveys conducted in the framework of the project mentioned in Chapter 4.2.1.6.

4.2.1.4 Source-specific quality assurance / control and verification (2.A.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For purposes of quality assurance, all data used, including data from the BDZ, from the VDZ and comparative data from the literature, were checked for plausibility. The determined emission factor for raw-material-related CO₂ emissions has been compared with the relevant figures of other countries. The small deviation (< 5 %) from the IPCC Tier 1 default factor of the IPCC Reference Manual, 0.5071 t CO₂ / t clinkers (IPCC 1996b: Chapter 2.3.2, p. 2.6), results from the sometimes-higher lime content of German clinkers (64 % to 67 % CaO) and an average MgO content, which is not taken into account in the default value, of 1.5 %. The procedure used corresponds to the Tier 2 method of the IPCC-GPG (IPCC, 2000), and it is considered to be more precise than utilisation of default emission factors.

The emission factor used differs only slightly (1 %) from the emission factor used in connection with the ETS in Germany, an emission factor which is checked by authorities and reviewed in light of companies' obligations to provide records. To date, no calculations relative to the emission factor prior to the year 2000 are available. The same figure – the result of an expert assessment – has been used for all relevant years in that period.

4.2.1.5 Source-specific recalculations (2.A.1)

No recalculations are required.

4.2.1.6 Source-specific planned improvements (2.A.1)

Working under commission to the Federal Environment Agency, the German Cement Works Association (VDZ) has carried out a project entitled "Emission factors for the cement industry" ("Emissionsfaktoren für die Zementindustrie")³¹. In the framework of this project, the emission factor used to calculate raw-material-related CO₂ emissions was confirmed on the basis of data from the year 2006. Pursuant to current findings, the cement industry's emissions are being properly described.

4.2.2 Mineral products: lime production (2.A.2)

4.2.2.1 Source category description (2.A.2)

CRF 2.A.2										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions		2009 – contribution to total emissions		Trend			
Kalk Produktion		I / -	CO ₂	0.51 %	0.48 %		-26.5 %			
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	D	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	+5/-12 ³²	--	--	--	--	--				
Distribution of uncertainties	L	--	--	--	--	--				
EF-determination method	CS	--	--	--	--	--				

The source category *Lime production* is a key category for CO₂ emissions in terms of emissions level.

The statements made below regarding source category 2.A.2 refer solely to the amounts of burnt lime and dolomite lime produced in German lime works. Information about other lime-producing and lime-using sectors is provided in Chapter 4.2.3 (CRF 2.A.3), in the interest of preserving the international comparability of Chapter 4.2.2 (CRF 2.A.2).

Because of the wide range of applications covered by the sector's products, lime production is normally more insulated from economic fluctuations than is production of other mineral products, such as cement. Production has fluctuated relatively little since the end of the 1990s. In 2009, production decreased by 20 % from the previous year, however, for economic reasons.

³¹ The complete title is: "Provision of a quality-assured database for emissions reporting for implementation of international air-quality-control and climate-protection agreements for selected industrial sectors – sub-project 3: cement industry" ("Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung internationalen Luftreinhalte- und Klimaschutzvereinbarungen für ausgewählte Industriebranchen – Teilvorhaben 03: Zementindustrie")

³² Weighted uncertainty for the areas of lime and dolomite (for individual uncertainties, cf. the CSE)

Table 75: Production and CO₂ emissions in the German lime industry

Year	Lime		Dolomite lime	
	Production	CO ₂ emissions	Production	CO ₂ emissions
	[t]	[Millions of t]	[t]	[Millions of t]
1990	7,180,057	5.636	591,595	0.540
1991	6,347,938	4.983	593,321	0.542
1992	6,434,344	5.051	575,955	0.526
1993	6,718,472	5.274	516,470	0.472
1994	7,365,100	5.782	505,995	0.462
1995	7,461,872	5.858	545,026	0.498
1996	6,881,431	5.402	545,575	0.498
1997	6,975,146	5.475	531,268	0.485
1998	6,666,164	5.233	558,373	0.510
1999	6,681,273	5.245	481,123	0.439
2000	6,856,478	5.382	525,522	0.480
2001	6,534,447	5.130	512,527	0.468
2002	6,462,040	5.073	516,271	0.471
2003	6,599,930	5.181	436,887	0.399
2004	6,561,720	5.151	459,679	0.420
2005	6,407,324	5.030	464,345	0.424
2006	6,515,915	5.115	462,533	0.422
2007	6,738,764	5.290	459,405	0.419
2008	6,733,805	5.286	455,066	0.415
2009	5,393,103	4.234	335,013	0.306

values in italics: provisional

Source: Own extrapolation on the basis of BV KALK, 2010

Production of dolomite lime, of which significantly smaller amounts are produced, basically exhibits similar fluctuations. On the other hand, production in the years 2003 to 2008 was considerably lower than in 2002 and the years before then (in 2003, production decreased by about 15 %). Between 1990 (the base year) and 2008, production decreased by about 23 %. Between 1990 and 2009, it decreased by 43 % (with an economically related production decrease, between 2008 and 2009, of more than 26 %).

With a constant emission factor, CO₂ emissions and lime / dolomite-lime production depend linearly on each other; as a result, the above statements apply to CO₂ emissions *mutatis mutandis*.

4.2.2.2 Methodological issues (2.A.2)

In burning of limestone and dolomite, CO₂ is released, and it reaches the atmosphere via the exhaust gas of the process. The pertinent emissions level is obtained by multiplying the amount of product in question (lime or dolomite lime) and the relevant emission factor.

Emission factors

The pertinent CO₂ emissions are calculated with the help of the relevant stoichiometric factors:

$$\begin{aligned} \text{EF}_{\text{lime}} &: 0.785 \text{ t CO}_2/\text{t lime} \\ \text{EF}_{\text{dolomite lime}} &: 0.913 \text{ t CO}_2/\text{t dolomite lime}. \end{aligned}$$

Here, it is assumed that 100 % of the lime consists of CaO, and that 100 % of the dolomite lime consists of CaO • MgO. This approach can lead to overestimation of emissions, since it does not take account of any impurities in the relevant raw materials or of any incomplete deacidification. In principle, this approach conforms to the specifications in *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*

(IPCC 2000, Chapter 3.1.2), and it maintains comparability with figures produced under other reporting obligations (for example, in the context of emissions trading).

Activity data

The German Lime Association (BVK) collects the production data for the entire time series, on a plant-specific basis, and makes them available for reporting purposes. As of this year, the quantities produced by plants that are not included in the German Lime Association's association statistics are estimated on the basis of existing information (such as operator figures, data published in the framework of emissions trading) and then added to the German Lime Association's figures. This ensures that all of German lime production is taken into account.

4.2.2.3 Uncertainties and time-series consistency (2.A.2)

The EU monitoring guidelines for emissions trading call for activity data to have an accuracy of 2.5 %. Since the German Lime Association's (BV Kalk's) lime-production data are based on operators' figures as provided in the framework of CO₂-emissions trading, and since the plants not included in the association's statistics (and thus assessed after the fact) represent only a small share of the total number of plants concerned, the **uncertainties** for the **activity data** used are estimated to be 2.5 % and +2.5 %. These figures apply to both burnt lime and dolomite lime.

The uncertainties for the emission factors used for burnt lime were estimated as -11 % and +5 %. The uncertainties for the emission factors used for dolomite lime were estimated as -30 % and +2 %.

4.2.2.4 Source-specific quality assurance / control and verification (2.A.2)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Production amounts are determined, by the BV Kalk association, via several different concurrent procedures; their quality is thus adequately assured (Tier 2).

The estimated emissions and collected production-quantity data were compared with findings from emissions trading and with national statistical data. The emission factors used were compared with the IPCC default factors. Both reviews confirmed the method used and the country-specific emission factors.

4.2.2.5 Source-specific recalculations (2.A.2)

No recalculations need to be carried out between the Resubmission 2010 and this year's report. Recalculations on the basis of the in-country review 2010 are presented in Chapter 10.5.2.5.

4.2.2.6 Source-specific planned improvements (2.A.2)

The emission factors determined, in the framework of a research project, on the basis of emissions declarations of German lime works (including works producing dolomite) are only of limited use for verification of the figures in the CSE. The completion of that project has been delayed.

4.2.3 Mineral products: Limestone and dolomite use (2.A.3)

4.2.3.1 Source category description (2.A.3)

CRF 2.A.3					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
- / -	CO ₂	IE	IE	-	

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	IE	NO	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %	--	--	--	--	--	--				
Distribution of uncertainties	--	--	--	--	--	--				
EF-determination method	--	--	--	--	--	--				

At present, emissions of this source category are not reported separately; instead, they are reported in the source categories that use limestone and dolomite. For the sake of simplicity, reference will be made to "limestone" (except in special cases requiring explanation), even where the sum of limestone and dolomite is meant.

In the framework of a research project entitled "limestone balance" ("Kalksteinbilanz"), all use of limestone and dolomite has been systematically balanced (cf. Table 76). In addition, suitable, annually available data sources have been selected for reporting, and the relevant calculations have been integrated within the national reporting system. In this source category, all production and use of limestone and dolomite are considered in balance form, and the results are compared with the inventory source categories. The "limestone balance" project provides a substance-flow analysis, in the form of amounts balance sheets that can be combined into time series. This methodological work was carried out in a research project that drew on all of the Federal Environment Agency's available expertise (UBA 2006). In 2010, that balance-sheet series was updated with the complete data record for 2008, i.e. up to the last year for which data was available. Evaluation of the series then identified problems in data availability. It proved possible to derive relevant solutions, however, and the impacts of use of the IPCC Guidelines 1996 and 2006 (i.e. the consequences of choice of Guidelines to apply) were shown. A pertinent short report that was prepared co-operatively, by the Federal Institute for Geosciences and Natural Resources (BGR) and the Federal Environment Agency, includes completely recalculated time series for limestone use (UBA 2010).

Table 76: Limestone balance sheet for use of limestone in areas with, and without, relevance with regard to carbon-dioxide emissions

Limestone use in Germany, in millions of tonnes					
[Millions of t]	1990	1995	2000	2008	CRF reference
Production					
Domestic production (change in statistics from 1994 to 1995)	110.500	76.790	95.100	91.659	2.A.3
Imports	1.299	2.275	3.301	5.214	2.A.3
Exports	0.201	0.389	0.278	1.367	2.A.3
Total production	111.598	78.676	98.123	95.506	2.A.3
Use					
Cement industry	34.203	35.131	34.522	29.601	2.A.1
Lime industry	13.733	14.143	13.031	12.319	2.A.2
Soda ash production	2.275	1.831	1.706	1.745	2.A.4
Glass production	0.700	0.890	0.970	0.902	2.A.7
Sintering (preparation of iron ores)	4.681	4.600	4.273	4.541	2.C.1
Pig iron (blast furnace)	0.756	0.751	0.924	0.790	2.C.1
Sugar production (lime furnaces)	0.686	0.784	0.796	0.655	2.D.2
Flue-gas desulphurisation in power stations	1.362	1.401	2.580	2.303	1.A.1.a
Agriculture and forestry	2.437	3.233	3.469	3.410	5.G
Water and sludge treatment	0.051	0.062	0.047	0.226	NE
Other areas (such as construction, other construction-materials industry and chemical industry, etc.)	50.716	15.851	35.804	39.014	NE
Total use	111.598	78.676	98.123	95.506	2.A.3
Auxiliary balance (limestone included in raw materials)					
Ceramics production					
- Brick production	1.028	1.384	1.190	0.751	2.A.7

Source: Compilation of the Federal Environment Agency, from UBA 2006 (Tab. 3-23; direct link <http://www.uba.de/uba-info-medien/3102.html>) and UBA 2010 (Tab. 1-2)

In terms of quantity, and taken together, emissions-related uses of limestone in cement and lime production have a significance similar to that of so-called "other areas". At the same time, emissions-related uses are showing a slightly decreasing trend, although their overall order of magnitude has not changed.

The balance-sheet calculations are designed solely to provide an overview of limestone use, i.e. to support verification of the activity-data bases for other source categories. The emissions are calculated for those source categories in which limestone is used.

4.2.3.2 Methodological issues (2.A.3)

The balance sheet of all limestone uses lists source categories in which limestone use leads to CO₂ emissions:

- 1.A.1.a Flue-gas desulphurisation in power stations (addition of limestone)
- 2.A.1 Cement-clinker production (limestone fraction in the relevant raw materials)
- 2.A.2 Lime production (limestone input)
- 2.A.7 Glass production (limestone fraction in the relevant raw materials)

- 2.A.7 Ceramic-brick production (limestone fraction in the relevant raw materials)
- 2.C.1 Iron and steel production (limestone input for raw iron and sinter)
- 5.B Soil liming in the agriculture and forestry sectors

Limestone is also used in other sectors that are not mentioned in the present section. Such uses either a) involve kilns for lime-burning, and thus are subsumed in the data compilation in 2.A.2, or b) produce no direct emissions, as is the case in soda ash and sugar production³³. With the exception of quantities used in production of ceramic products, all limestone quantities used are included in production as determined and thus can be derived from the limestone balance (sheet).

In spite of the consistency of the limestone balance sheet, the resulting CO₂ emissions can be calculated more precisely, and in ways that are more specifically suitable, in source categories with a sectoral focus. For example, the natural limestone fraction in raw materials used for brick production can be estimated. That fraction is taken into account source-category-specifically in 2.A.7, along with emissions-causing porosity agents. The uses considered source-category-specifically for the glass industry, in 2.A.7, include much more than limestone use – for example, they also include use of soda ash and other carbonates.

As a result, the pertinent data are updated in the relevant source categories (cf. the above list). In addition, pertinent methodological aspects are explained in the relevant source-category chapters (cf. chapters 3.2.6, 4.2.8, 4.4.1).

To prevent double-counting with other source categories, and to ensure comparability with future inventories, in keeping with IPCC GL 2006, no CO₂ emissions are aggregated in the present section. In this regard, cf. also the following comparison:

Relevance to the IPCC Guidelines

The IPCC Guidelines 2006 (GL 2006), which are not yet applicable, but are methodologically more refined than earlier guidelines, call for emissions from use of limestone and other carbonates to be calculated in the context of those source categories in which the relevant uses occur. All emissions-related balance entries are calculated and reported at suitable locations in the global consideration pursuant to GL 2006. Separate designation as "limestone use", in addition to inclusion within category-specific calculations, is no longer required in such calculation and reporting³⁴.

When, in CRF category 2.A.3, the rules of the IPCC Guidelines 1996 (GL 1996) are strictly followed, all explicitly specified limestone uses are described and the emissions for all such uses are calculated and summed, a distorted picture of the importance of emissions from limestone use results. In updating of the limestone balance sheet, such distortion was studied, also with regard to different possibilities for deriving limestone-input quantities. If source-category-specific circumstances were not taken into account, only balance-sheet positions based on statistical data could be aggregated under 2.A.3. In the source categories themselves, by contrast, limestone inputs can be calculated on the basis of actual requirements, although such results, along with the pertinent emissions, can hardly be deducted in any transparent manner.

³³ This refers to the process in which limestone is burned to obtain CO₂, which then recarbonises in cleaning processes. The pertinent CO₂ emissions occur only when lime is applied in agriculture (carbolic lime); this is reported under CRF 4 and 5.

³⁴ There does continue to be a separate position 2A4 "Other Process Uses of Carbonates", but that position would have no application within the context of German emissions inventories.

Table 77: Comparison of balance-sheet positions with emissions relevance pursuant to GL 1996 (report category 2.A.3), for 2008, as gained from model calculations with specific key figures ("from key figures") and from statistical information ("statistical")

Figures in millions of tonnes in 2008				
Balance-sheet position (limestone use with CO ₂ emissions)	CO ₂	2.A.3 ³⁵	From key figures	Statistical
1.A.1.a Flue-gas desulphurisation (REA) in large combustion installations	x	x	2.303	1.745
2.A.7 Glass production (total)	x	x	0.902	0.356
2.A.7 Ceramics production (external "auxiliary balance")	x	x	0.751	0.000
2.C.1 Iron and steel production	x	x	5.331	3.437
CO₂ emissions from limestone (for simplicity, calculated with dolomite included)	x	x	4.1 (CO₂)	2.4 (CO₂)

Source: Calculation of Federal Environment Agency (UBA); Table 3 from UBA 2010

The comparative emissions described here are not included in aggregated form in the CRF tables for 2.A.3, and they not included, in aggregated form, in key-source determination. The source-category-specifically calculated emissions are included in the aforementioned source categories, however, and they have been included in key-source determination for those categories³⁶.

4.2.3.3 Uncertainties and time-series consistency (2.A.3)

Information regarding uncertainties for activity data and emission factors for the relevant limestone uses is provided in the relevant source-category chapters.

4.2.3.4 Source-specific quality assurance / control and verification (2.A.3)

General quality control and quality assurance, in keeping with the requirements of the QSE manual and its associated documents, have been carried out in those source categories into which source category 2.A.3 was divided, pursuant to the IPCC Guidelines.

The activity data and the emission factors for the relevant limestone uses are verified and updated in the relevant source categories.

The data surveys from the limestone-balance research project, and the updating carried out by the Federal Institute for Geosciences and Natural Resources (BGR) and the Federal Environment Agency, do not point to any persisting inventory gaps, and thus the surveys are considered adequate.

Allocation of limestone uses was intensively discussed in connection with the 2010 inventory review, but no pertinent inventory adjustments were derived.

4.2.3.5 Source-specific recalculations (2.A.3)

The recalculations have been described and explained in those source categories in which limestone inputs are significant. For the present report, slight recalculations were carried out in the areas of flue-gas desulphurisation (Chapter 19.1.2.3) and soil liming (Chapter 7.3.7).

³⁵ IPCC 1996

³⁶ Limestone use under 1.A.1.a and under 2.C.1 is included in key sources determined pursuant to Tier 1.

4.2.3.6 Source-specific planned improvements (2.A.3)

No improvements, and no annual updating of the limestone balance sheet, are planned at present.

4.2.4 Mineral products: Soda ash production and use (2.A.4)

4.2.4.1 Source category description (2.A.4)

CRF 2.A.4					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
		- / -			

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO / D	NO	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %	+2%/-2%									
Distribution of uncertainties	N									
EF-determination method	CS									

The source category "Soda ash production and use" is not a key source.

In Germany, soda ash is produced only chemically. The country has 3 production facilities, all of which use the Solvay process³⁷. With respect to the calcium carbonate it uses, that process is CO₂-neutral, since the carbon dioxide in the limestone is bound within the product, soda ash (Na₂CO₃), and is released only during product use.

On the other hand, coke is used in the calcination part of the process, and this produces additional carbon-dioxide emissions. An amount of some 100 kg of coke is assumed per tonne of soda ash; this was determined in a research project for the preparation of relevant Best Available Technique Reference Documents (BREF) (UBA, 2001). While this corresponds to an amount of some 380 kg CO₂ / t soda ash, these emissions are reported not here but together with energy-related emissions.

Soda ash is used in a wide range of industrial applications. The most important areas of use include the glass industry, production of detergents and cleansers and the chemical industry. It is assumed that the carbon contained in soda ash is released sooner or later, regardless of the use involved, into the air as CO₂.

Emissions resulting solely from use of soda ash correlate in a fixed way to the pertinent calculated quantities used (cf. the methodological issues in the following):

³⁷ Ammonia-soda process developed by Ernst Solvay

Table 78: Activity data and use-related CO₂ emissions since 1990

Year	Activity data [t]	CO ₂ emissions [t]
1990	914,216	379,400
1991	696,118	288,889
1992	515,347	213,869
1993	494,172	205,081
1994	547,558	227,237
1995	480,997	199,614
1996	474,395	196,874
1997	529,520	219,751
1998	585,793	243,104
1999	534,029	221,622
2000	555,898	230,698
2001	620,243	257,401
2002	565,614	234,730
2003	640,334	265,739
2004	613,591	254,640
2005	632,114	262,327
2006	612,501	254,188
2007	636,873	264,302
2008	626,439	379,400
2009	541,774	224,836

Source: Calculations of the Federal Environment Agency (UBA)

4.2.4.2 Methodological issues (2.A.4)

Activity data

The *Federal Statistical Office* determines the total amounts of soda ash produced in Germany. From 1995 to 2008, the sum total has comprised the categories of *light soda* (production number 2413 33 103, disodium carbonate in powder form, with a fill density of less than 700 g/l) and *heavy soda* (production number 2413 33 109, other disodium carbonate). Since 2009, light and heavy soda are reported in combination, in one position (notification number 2013 43 100). Of that quantity, only the portion "intended for sale" ("zum Absatz bestimmt") is taken into account. This prevents double-counting, since heavy soda is produced from light soda.

Since the 2010 inventory review, those soda ash inputs are determined that are not taken into account, for emissions calculations, in other source categories. The relevant calculations are oriented to the greatest possible emissions from the applicable soda ash use. The total quantity of soda ash used in Germany is determined via balancing (quantity produced plus imports and less exports). The relevant import and export quantities are taken from the foreign-trade statistics of the Federal Statistical Office (STATISTISCHES BUNDESAMT, 2010a). Emissions from soda ash use in the glass industry are already taken into account, source-specifically, under source category 2.A.7 (Glass industry). The soda ash quantities used in that category are calculated from the mixtures of glass types used, and then deducted from the soda ash use of relevance in the present section.

Since Germany has only two producers, these newly structured data must be kept confidential. Only the production quantities reported by the Federal Statistical Office through 2008 continue to be published.

Emission factor

Since the Solvay production process is neutral with regard to CO₂, an emission factor of "0" is used for production.

The amounts of coke that are converted into CO₂ during lime burning are already taken into account in the Energy Balance, without being listed separately with regard to their CO₂ emissions.

Stoichiometrically, the emission factor for soda ash use is 415 kg CO₂ per tonne of soda ash, under the assumption that release is complete (a conservative approach). The emission factor is in keeping with the relevant IPCC requirements (IPCC, 1996b).

4.2.4.3 Uncertainties and time-series consistency (2.A.4)

Activity data

There are uncertainties regarding the production statistics given by the Federal Statistical Office, since – for example – the relation between light and heavy soda ash fluctuates widely, especially in the first years for which separate statistics are provided. Because production is emissions-neutral, readers seeking further details are referred to the NIR 2007.

The calculations of the relevant quantities of soda ash used exhibit large uncertainties (maximally, -50%/+50%), as a result of both statistical fluctuation ranges and the assumptions on which the calculations are based.

Emission factor

Since the emission factor for production of soda ash is a substantiated "zero", there is no uncertainty. The emission factor for soda ash use is subject to small, justified uncertainties in the area of product purity and the completeness of the chemical transformations involved.

4.2.4.4 Source-specific quality assurance / control and verification (2.A.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Currently, the method of calculating the soda quantities used cannot be verified. As a conservative estimate, however, it by no means underestimates the relevant quantities for the inventory.

4.2.4.5 Source-specific recalculations (2.A.4)

No recalculations need to be carried out between the Resubmission 2010 and this year's report. Recalculations on the basis of the in-country review 2010 are presented in Chapter 10.5.2.6.

4.2.4.6 Source-specific planned improvements (2.A.4)

No specific improvements are planned at present. In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.

4.2.5 Mineral Products: Bitumen for roofing (2.A.5)

CRF 2.A.5				
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
	- / -			

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

As far as is currently known, the source category "*Bitumen for roofing*" produces no greenhouse-gas emissions and is thus not a key source.

4.2.5.1 Source category description (2.A.5)

Bitumen is used in production and laying of roof and sealing sheeting.

In 2009, some 169 million m² of roof and sealing sheeting were produced in Germany, and some 142 million m² of such sheeting were used (export surplus). In such production, liquid bitumen is applied, at temperatures of 150°C to 220°C, as a saturating or coating agent. This process produces emissions of organic substances (combined here as NMVOC).

Roof and sealing sheeting is laid by means of both hot and cold processes. The hot process, involving welding of sheeting, produces significant emissions of organic substances. The relevant emissions trends depend primarily on trends in quantities of polymer bitumen sheeting produced. Use of solvent-containing primers is not considered here; it is covered via the solvents model – cf. Chapter 5.2.

Emissions from production of roof and sealing sheeting have been decreasing slightly, in keeping with decreasing production quantities. Emissions from laying of roof and sealing sheeting have remained about the same, although the quantities used have been decreasing.

Other substances are of only subordinate relevance in terms of emissions.

4.2.5.2 Methodological issues (2.A.5)

The quantity of roof and sealing sheeting produced (**activity data**) has been provided by the Verband der Dachbahnenindustrie roof-sheeting manufacturers association (VDD, 2010), ever since a relevant cooperation agreement was concluded. At present, no data supplementation or extrapolation are being carried out. To obtain internationally comparable figures, production quantities are converted into quantities of input bitumen (the conversion relationship, depending on the type of sheeting concerned, varies from 1.3 to 3.3 bitumen kg/m²).

Because of their predominating importance, only NMVOC emissions are considered and taken into account in the emissions inventory. In the process, a distinction is made between emissions from production and emissions from laying of roof and sealing sheeting.

The **emission factor** for production of roof and sealing sheeting was obtained via a calculation in accordance with current technological standards of German manufacturers (VDD, 2009). The emission factor for laying of polymer bitumen sheeting has been taken

from an ecological balance sheet (IKP, 1996). That emission factor has also been adopted, by analogy, for sheeting glued primarily with hot bitumen. Thin sheeting is not glued; it is attached via nailing and produces no emissions. The implied emission factor for the source category has been increasing slightly, as a result of the increasing importance of polymer bitumen sheeting.

NMVOC emissions are calculated in keeping with a Tier 1 method, since no pertinent detailed data are available.

Table 79: Production and laying of roof and sealing sheeting with bitumen, and relevant activity data and emission factors

	Produced or used area in 2008 [millions of m ²]	EF/ IEF [kg/ m ²]
Production of roof and sealing sheeting with bitumen	169	NMVOC 0.00035795
Laying of roof and sealing sheeting with bitumen	142	NMVOC 0.000027 – 0.000038

4.2.5.3 Uncertainties and time-series consistency (2.A.5)

Information relative to the uncertainty of the data of the VDD was obtained via consultation between the VDD and the Federal Environment Agency. The total uncertainty for the activity data for production and laying of sheeting is estimated to be about +/-1 %. That figure, in turn, leads to a higher uncertainty, of about +/-2.5 %, for the calculated bitumen consumption.

The uncertainty for the combined emission factors for production and laying of roof and sealing sheeting is estimated to be about +/-5 %.

4.2.5.4 Source-specific quality assurance / control and verification (2.A.5)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity on the basis of updated association data.

The manner in which the activity data were determined is considered to be plausible. The emission factors accord with findings from pertinent Federal Environment Agency research projects and are plausible. In particular, the validity of the emission factors is justified in that no emissions from use of solvent-containing coatings and primers have to be taken into account in this section (that takes place in the solvents model, as noted above).

4.2.5.5 Source-specific recalculations (2.A.5)

Addition of lacking emission factors for use of one type of sheeting has necessitated minor recalculations, leading to higher emissions for the entire time series.

4.2.5.6 Source-specific planned improvements (2.A.5)

The VDD plans to carry out additional considerations relative to export-import offsetting.

4.2.6 Mineral Products: Road paving with asphalt (2.A.6)

CRF 2.A.6				
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
- / -				

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	NO	NO	NO	NO	CS	IE	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

As far as is currently known, the source category "Road paving with asphalt" produces no greenhouse-gas emissions and is thus not a key source.

4.2.6.1 Source category description (2.A.6)

Currently, the report tables list produced quantities of mixed asphalt products and NMVOC, NO_x and SO₂ emissions.

In 2009, a total of about 55 million t of asphalt (DAV, 2010) was produced in Germany, in a total of some 700 asphalt-mixing plants. Asphalt is used primarily in road construction, where it competes directly with concrete. In 1991, production increased considerably. Since 2000, the quantity produced has generally been decreasing. In 2009, it increased slightly as a result of economic-stimulus programmes.

The relevant emissions trends depend primarily on trends in production quantities.

4.2.6.2 Methodological issues (2.A.6)

No special calculation procedure is available for calculating fuel inputs in source category 1.A.2. Nonetheless, fuel inputs are taken into account via Energy Balance evaluation, and they are coupled with suitable emission factors.

The applicable quantity of mixed asphalt products produced (**activity data**) has been taken from communications of the Deutscher Asphaltverband (DAV; German asphalt association).

Emission factors have been determined country-specifically, pursuant to Tier 2. For determination of emission factors for substances other than CO₂, emissions measurements from over 400 asphalt-mixing plants, made during the period 1989 through 2000, were used. The majority of the emissions occur during drying of pertinent mineral substances. Almost all of the NMVOC emissions originate in the organic raw materials used, and they are released primarily in parallel-drum operation, as well as from mixers and loading areas. On average, about 50% of the NO_x and SO₂ involved come from the mineral substances (proportional process emissions). CO occurs primarily in incomplete combustion processes. CO emissions are calculated solely in connection with fuel inputs.

Table 80: Emission factors for production of mixed asphalt products

	NO _x	NM VOC	SO ₂
EF [kg/ t]	0.015	0.030	0.030

Only emissions from asphalt production are reported. Figures relative to emissions released during laying of asphalt have not yet been adequately reviewed.

4.2.6.3 Uncertainties and time-series consistency (2.A.6)

As the extensive measurement data show, the emissions lie within a comparatively narrow range. The large volume of measurement data available makes it possible to form highly reliable mean values. The only large uncertainties are found in breakdown of emissions amounts into fuel-related and process-related emissions.

The production-amount data may be considered very accurate, since the product in question is a sale-ready product, and operators report the relevant amounts to the DAV.

4.2.6.4 Source-specific quality assurance / control and verification (2.A.6)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

The relevant country-specific emission factors are being evaluated in a research project.

4.2.6.5 Source-specific recalculations (2.A.6)

No source-specific recalculations were required.

4.2.6.6 Source-specific planned improvements (2.A.6)

Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.

4.2.7 Mineral products: Glass production (2.A.7 Glass)

CRF 2.A.7 Glas					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
- / -					

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	+/- 10									
Distribution of uncertainties	N									
EF-determination method	CS									

The source category "Mineral products: glass production" is not a key source.

4.2.7.1 Source category description (2.A.7 Glass)

Germany's glass industry produces a wide range of different glass types with different chemical compositions. Germany's glass sector comprises the following sub-sectors:

container glass, flat glass, domestic glass, special glass and mineral fibres (glass and stone wool). The largest production quantities, by percentage, are found in the sectors of container glass (about 56 % of total glass production in 2009) and flat glass (about 26 % of total glass production in 2009). Together, these sectors account for 82 % of total glass production (BV Glas, 2010).

A large number of primary and secondary raw materials are used. A distinction is made between natural raw materials, synthetic raw materials and the additives used in small amounts (refining agents, colouring agents and decolouring agents). The most important natural raw materials include sand, limestone, dolomite, feldspar and igneous rocks. The most important synthetic raw material used in production of high-volume glasses such as flat glass and container glass is soda ash (cf. also 4.2.4.1). Glass cullet (including cullet from within production operations and from outside sources) is an important secondary raw material.

In production, homogeneous glass mixtures combining primary and secondary raw materials are melted down at temperatures between 1,450 °C and 1,650 °C. The process-related CO₂ emissions under consideration here are released from the raw-material carbonates during the melting process in the oven. CO₂ emissions – in smaller amounts – also occur in neutralisation of HF, HCL and SO₂ in exhaust gases, with the help of limestone or other carbonates. Because the amounts involved are so small, these emissions are not considered here.

The following table shows the trends, since 1990, in activity data, process-related CO₂ emissions and the implied emission factors resulting for all glass types overall.

Table 81: Activity data and process-related CO₂ emissions since 1990

Year	Activity data [t]	Process-related CO ₂ emissions [t]	IEF for all glass types as a whole [t CO ₂ / t _{glass}]
1990	6,561,849	695,617	0.106
1991	7,202,807	733,252	0.102
1992	7,228,752	718,117	0.099
1993	7,074,837	684,797	0.097
1994	7,760,000	651,580	0.084
1995	7,621,300	774,525	0.102
1996	7,519,600	750,079	0.100
1997	7,392,000	717,713	0.097
1998	7,314,000	694,763	0.095
1999	7,442,239	703,752	0.095
2000	7,505,000	731,039	0.097
2001	7,293,000	733,511	0.101
2002	7,084,000	690,484	0.097
2003	7,205,720	694,407	0.096
2004	7,088,900	696,613	0.098
2005	6,948,400	705,910	0.102
2006	7,285,600	734,991	0.101
2007	7,559,000	759,347	0.101
2008	7,514,000	753,713	0.100
2009	6,748,600	690,155	0.101

It is clear that emissions tend to follow the trend in activity data. At the same time, the implied emission factors indicate that the correlation is not rigid; some discrepancies do occur. The

discrepancies are due to annual fluctuations in production quantities of various individual glass types, and in cullet inputs. They are thus logical and calculatory correct.

4.2.7.2 Methodological issues (2.A.7 Glass)

The currently valid *IPCC Good Practice Guidance (2000)* contains no proposals or information relative to calculation of process-related CO₂ emissions for the glass industry. In keeping with the general recommendations of the *IPCC Good Practice Guidance*, therefore, a special method had to be developed. The NIR 2007 provides a detailed discussion of the relevant methods (Chapter 4.1.7.2, p. 251ff).

The CO₂ emissions (the main pollutant) are calculated via a Tier 2 method, because the activity data are tied to specific emission factors (that are in keeping with the relevant carbonate concentrations). The following carbonates are taken into account as the main sources of CO₂ formation during the melting process: calcium carbonate (CaCO₃), soda / sodium carbonate (Na₂CO₃), magnesium carbonate (MgCO₃) and barium carbonate (BaCO₃). In the present context, the CO₂ emissions are reported; raw-materials inputs – limestone and soda ash – are considered under 2.A.3 (cf. 4.2.3) and 2.A.4 (cf. 4.2.4), respectively.

The production figures (**activity data**) are taken from the regularly appearing annual reports of the national glass industry association (Bundesverband Glasindustrie; BV Glas, 2010). "Production" refers to the amount of glass produced, which is considered to be equivalent to the amount of glass melted down. Further processing and treatment of glass and glass objects are not considered.

The following activity data were determined for 2009:

Table 82: Glass: Activity data for the various industry sectors (types of glass)

Industry sector	Activity data for 2009 [thousands of t]
Container glass	3778.9
Flat glass	1734.7
Special glass	321.3
Domestic glass	240.6
Glass fibre and wool	237.7
Stone wool	435.4

Source: BV Glas, 2010

The following sector-specific cullet percentages are assumed:

Table 83: Cullet percentages for the various types of glass

Industry sector	Cullet percentage [%] in the input raw material
Container glass	59 – 65 (annually varying)
Flat glass	35 (entire time series)
Special glass	30 (entire time series)
Domestic glass	20 (entire time series)
Glass fibre and wool	40 (entire time series)
Stone wool	40 (entire time series)

Source: HVG, 2008

The cullet percentage for container glass is known only for the western German Länder as of 1990. For Germany as a whole, it is known for the period since 1995. No data are available for the new German Länder for the period from 1990 to 1994. For that reason, an average

cullet percentage input was estimated on the basis of the various glass sectors' average percentages of total glass production. In 2007, the firm of Gesellschaft für Glasrecycling und Abfallvermeidung mbH (GGA) was forced to cease operations, under cartel law. As a result, no reliable cullet-input data have been available from that source since 2007. For the time being, the relevant data are being cross-checked against quantity surveys pursuant to the Ordinance on Packaging (Verpackungs-Verordnung) and against waste-management data provided by the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, Fachserie (specialised series) 19 Reihe (series) 1, Table 1.2). At present, the last available GGA data are being updated.

Since the exhaust gases occurring during the melting process are drawn off together with combustion-related exhaust gases – i.e. as a collective exhaust-gas stream – measurements cannot be used to determine the CO₂ quantities produced by the German glass industry. For this reason, a calculation procedure is used that is based on the weight shares for the aforementioned carbonates and on cullet input in the container-glass and flat-glass industry. Figures on the chemical composition of the various types of glass produced in Germany have been taken from VDI-Richtlinie (guideline) 2578 (VDI, 1999) and from the ATV-DVWK Merkblatt (standards sheet of the German Association for Water, Wastewater and Waste) 374 (ATV, 2004).

The procedure used to determine **emission factors** for the various glass oxides involved and the pertinent emissions is described in detail in the NIR 2007 (Chapter 4.1.7.2, p. 251ff).

The following emission factors were calculated for the various industry sectors. The factors vary annually in keeping with variations in cullet inputs (and thus ranges are given):

Table 84: CO₂-emission factors for various glass types (calculated in comparison with figures from the CORINAIR manual)

Glass type	Calculated emission factor [kg CO ₂ / t _{molten glass}] - stoichiometric / incl. cullet input-		Default emission factors [kg CO ₂ / t _{molten glass}] - pursuant to CORINAIR -	
Container glass	193	/ 49 - 86	171	- 229
Flat glass	208	/ 135	210	
Domestic glass	120	/ 96	-	
Special glass	113	/ 79	0	- 178
Glass fibre	198	/ 119	0	- 470
Stone wool	299	/ 179	238	- 527
Unspecified	174	/ 139	-	

4.2.7.3 Uncertainties and time-series consistency (2.A.7 Glass)

The production data have been taken from the internal statistics of the BV Glas glass-industry association. Since that association represents nearly all of Germany's container-glass and flat-glass manufacturers, the sectoral data it provides are highly accurate. An uncertainty of 5 % was thus assumed. The association's representation of all other glass sectors is incomplete, and thus the association cannot guarantee the completeness of the data for such other sectors. For this reason, an uncertainty of 10 % was assumed for those areas. Until about 2002, BV Glas also compared the data with data of the *Federal Statistical Office*.

The uncertainty in the cullet figures for container glass lies within the customary range for statistical determinations. For the new German Länder, an uncertainty of 20 % has been assumed, because no statistical survey has been carried out; only an estimate is available.

Updating of GGA figures, in connection with comparisons with cullet inputs as determined from waste statistics, increases the uncertainties. As part of this effect, the data are obtained from waste-treatment installations. As a result, the data lack the cullet quantities delivered directly from the dual systems to glass producers. What is more, the data do not show whether processed container-glass waste is used in glass furnaces. In addition, the data lack information regarding cullet imports and exports. Cross-checking of the data from 2007 (53 %) shows good agreement with the assumed pertinent value of 60 %.

The figures on cullet use for all other glass types are considerably less precise, however, since only estimates are available for those areas. An uncertainty of 20 % was thus assumed. That uncertainty is also assumed for container glass as of 2007.

As to CO₂-emission factors, an uncertainty of 10 % was assumed, for all industry sectors.

4.2.7.4 Source-specific quality assurance / control and verification (2.A.7 Glass)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The calculated emission factors were compared with several different sources, including the CORINAIR manual and the "Baden-Württemberg 2004 emissions declaration" ("Emissionserklärung 2004 Baden-Württemberg"; UMEG 2004). According to that comparison, the calculated emission factors may be considered accurate.

The calculated emissions were also cross-checked against the ETS data for Germany. In the process, a need for further checking was determined, since slightly higher carbon-dioxide emissions are reported in the framework of emissions trading than can be calculated via the inventory methods described here. Since that result is not plausible for a sector that tends to be incompletely reflected within the ETS, it will be necessary to search for the reasons for that result.

The information provided regarding the chemical composition of the various glass types continues to be considered correct in the present context. The applicable rate of cullet input, for which inadequate data are available (cf. Chapter 4.2.7.3 Uncertainties and time-series consistency (2.A.7 Glass)).

4.2.7.5 Source-specific recalculations (2.A.7 Glass)

No source-specific recalculations have been carried out.

4.2.7.6 Source-specific planned improvements (2.A.7 Glass)

At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.

4.2.8 Mineral Products: Ceramics production (2.A.7 Ceramics)

CRF 2.A.7 Keramik					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
	- / -				

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	+/-30									
Distribution of uncertainties	N									
EF-determination method	CS									

The source category "*Mineral products: ceramics production*" is not a key source.

4.2.8.1 Source category description (2.A.7 Ceramics)

The process-related emissions in the ceramics industry originate in the following sub-category elements:

1. "Production of ceramic products": This time series shows the quantity produced by the entire ceramics industry in Germany. These activity data are used to calculate the entire ceramics industry's emissions of NEC pollutants and dust. Process-related CO₂ emissions, on the other hand, are calculated only for the sub-quantities "roof tiles" and "masonry bricks" (see below).
2. "Brick production" (CO₂); "roof tile" product: Production of roof tiles is a subset of the aforementioned activity data for the entire ceramics industry. It is used only for calculation of process-related CO₂ emissions (with consideration of proportions of limestone and organic impurities).
3. "Brick production" (CO₂); "masonry brick" product: Production of masonry bricks is also a subset of the aforementioned activity data for the entire ceramics industry. This production figure is also used only for calculation of process-related CO₂ emissions (with consideration of porosity agents, as well as of proportions of limestone and organic impurities in the pertinent raw materials).

Table 85: Activity data and process-related CO₂ emissions in the ceramics industry (CRF 2.A.7.b)(rounded)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	[kt]										
Ceramics products	21595	20772	22769	24534	30458	24730	22663	22939	22798	22395	21199
of which:											
Masonry bricks	16524	15691	17302	18827	23925	18827	16965	17298	17048	16591	15383
Roof tiles	1758	1946	2216	2349	2611	2466	2598	2521	2658	2849	2924
Process-related CO2 emissions											
Masonry bricks	481	457	503	548	696	548	494	503	496	483	448
Roof tiles	50	56	63	67	75	71	74	72	76	81	84
Total	531	512	567	615	771	618	568	575	572	564	531
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
	[kT]										
Ceramics products	21199	18003	16500	16443	16796	14643	16019	16035	13867	12866	
of which:											
Masonry bricks	15383	12771	11686	11631	11697	9881	10883	10885	9302	9058	
Roof tiles	2924	2642	2381	2383	2601	2485	2648	2618	2254	1919	
Process-related CO2 emissions											
Masonry bricks	448	372	340	338	340	288	316	317	271	264	
Roof tiles	84	76	68	68	74	71	76	75	64	55	
Total	531	447	408	407	415	359	392	392	335	319	

4.2.8.2 Methodological issues (2.A.7 Ceramics)

The IPCC Good Practice Guidance contains no proposals or information relative to calculation of process-related CO₂ emissions for the ceramics industry.

The CO₂ emissions are calculated via a Tier 1 method, because no detailed data are available and because this source category is not a key source.

Activity data

Official statistics are of limited use in determining actual production trends in the brick industry, in terms of weights, since such statistics list production of masonry bricks and blown-clay products in cubic metres, and production of tiles in square metres and production of roof tiles in numbers of tiles. Produced weight quantities can be determined only via conversion factors. The conversion factors used for masonry bricks and roof tiles consist of values obtained by the Bundesverband der Deutschen Ziegelindustrie (German brick-industry association) from experience.

Emission factors

Process-related CO₂ emissions originate in the raw materials for production of roof tiles and masonry bricks (normally, locally available loams and clays with varying concentrations of CaCO₃ (limestone) and, in some cases, with organic impurities). On the basis of information from the German brick-industry association (Bundesverband der deutschen Ziegelindustrie), an emission factor of 28.6 kg/t_{product} is assumed for process-related CO₂ emissions from CaCO₃ and organic impurities in raw materials. That figure corresponds to a mean CaCO₃ fraction of 65 kg/t in the raw meal.

Porous masonry bricks account for about half of all masonry bricks produced in Germany. They are produced by adding organic porosity agents to the raw materials. When the bricks are fired, these agents burn, creating hollows. Most of the porosity agents used are renewable resources (such as sludges from the paper industry, spent liquors from pulp production). Non-renewable substances (especially polystyrene) are also used, however. The resulting CO₂ emissions are minimal by comparison to those from the limestone fractions in the raw materials. Nonetheless, they are taken into account in the inventory via a slightly higher CO₂-emission factor for masonry bricks (29.1 kg CO₂/t masonry bricks, as opposed to 28.6 kg CO₂/t for roof tiles).

The determined activity data and resulting CO₂ emissions are shown in Table 85. The process-related CO₂ emissions for this sub - source category, at considerably less than one million tonnes of carbon dioxide, are not particularly important.

4.2.8.3 Uncertainties and time-series consistency (2.A.7 Ceramics)

Due to the need for conversion of area and volume figures into produced quantities, the uncertainty for the three activity data is estimated at +/- 20 %; no other uncertainty factors are relevant.

The uncertainties for the **CO₂-emission factors** used for production of masonry bricks and roof tiles are determined primarily by the uncertainty relative to the CaCO₃ quantities contained in the raw materials (+/- 30 %).

The time series are consistent for activity data for production of masonry bricks and roof tiles, and the related CO₂-emission factors are consistent as well. Some changes have occurred, throughout the time series, in availability of statistics for various product types. These changes accounted for only about 1 % of the amounts of bricks produced, and for less than 0.5 % of total ceramics production, however.

The **activity data** for total ceramics production contains a methods discontinuity that results from a substantial change in the available statistical data. For masonry bricks and roof tiles, figures in thousands of t were available until 1994. As of 1995, the figures are only in thousands of m³ or thousands of units (piece count). In the NIR 2007, the relevant impacts are discussed in detail. On the other hand, the methods discontinuity is irrelevant with regard to CO₂ emissions.

4.2.8.4 Source-specific quality assurance / control and verification (2.A.7 Ceramics)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data from greenhouse-gas emissions trading cannot be compared directly with relevant emissions data from the National Inventory. The reason for this is that, in emissions trading, installations (plants) are included and grouped in accordance with threshold values, and thus data are available for only part of the ceramics industry – and only for some brick and roof-tile producers. A comparison of emissions since the year 2005 shows, however that the pertinent emissions reported in the National Inventory are some 20-30 % higher than the corresponding emissions in the context of emissions trading. For the aforementioned reason, this discrepancy, and its magnitude, seem plausible.

4.2.8.5 Source-specific recalculations (2.A.7 Ceramics)

No recalculations are required.

4.2.8.6 Source-specific planned improvements (2.A.7 Ceramics)

No improvements are planned at present.

4.3 Chemical industry (2.B)

Source category 2.B is sub-divided into sub-categories 2.B.1 through 2.B.5. These include ammonia production (2.B.1), nitric acid production (2.B.2), adipic acid production (2.B.3) and carbide production (2.B.4).

In the CSE, sub-category *Other* (2.B.5) includes fertiliser and nitrous oxide production, organic products, soot and titanium-oxide production, sulphuric acid production and coke burn-off in catalyst regeneration in refineries.

4.3.1 Chemical industry: Ammonia production (2.B.1)

4.3.1.1 Source category description (2.B.1)

CRF 2.B.1										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions		2009 – contribution to total emissions		Trend			
Ammonia Production		I / t	CO ₂	0.47 %	0.73 %		+19.1 %			
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	PS	NO	NO	NO	NO	NO	D	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	T3									

The source category "*Chemical industry: ammonia production*" is a key source of CO₂ emissions in terms of emissions level and trend.

Ammonia is produced on the basis of hydrogen and nitrogen, using the Haber-Bosch process, which also forms CO₂. Hydrogen is produced from synthetic gas based on natural gas, via a highly integrated process, *steam reforming*, while nitrogen is produced via air dissociation.

The various plant types for the production of ammonia cannot be divided into individual units and be compared as independent process parts, due to the highly integrated character of the procedure. In *steam reforming*, the following processes are distinguished:

- ACP – *advanced conventional process* with a fired primary reformer and secondary reforming with excess air (stoichiometric H/N ratio)
- RPR – *reduced primary reformer process*, carried out under mild conditions in a fired primary reformer, and with secondary splitting with excess air (sub-stoichiometric H/N ratio)
- HPR – *heat exchange primary reformer process* – autothermic splitting with heat exchange using a steam reformer heated with process gas (heat exchange reformer) and a separate secondary reformer or a combined autothermic reformer using excess air or enriched air (sub-stoichiometric or stoichiometric H/N ratio).

The following procedure is also used:

- Partial oxidation – Gasification of fractions of heavy mineral oil or vacuum residues in production of synthetic gas.

Ammonia is produced at five locations in Germany. The production operations use both the steam-reforming and partial-oxidation processes.

The production decrease of more than 15 % (corresponding to an amount of nearly 300 kt) in the first year after German reunification was the result of a market shake-up, over 2/3 of which was borne by the new German Länder. The production level then remained nearly constant in the succeeding years until 1994. It has not been possible to determine the reason for the renewed growth as of 1995, which returned production to the level seen in 1990. However, the growth could be due to resumption of production processes in the new German Länder, following extensive modernisations. Since 1995, production levels have fluctuated only slightly.

4.3.1.2 Methodological issues (2.B.1)

In keeping with this source category's categorisation as a key source of CO₂ emissions, as of the 2010 report, emissions data for this source category are being collected and reported in accordance with the Tier 3 standard. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data.

The operators transmit their data to the Industrieverband Agrar (IVA) agrochemical industry association. After carrying out quality assurance, that association then aggregates the data, to protect confidentiality, and forwards the resulting aggregated data to the Federal Environment Agency.

Plant operators report the following to the IVA:

- Ammonia quantities produced (**activity data**),
- The quantities of raw materials used in the process (natural gas, heavy mineral oil), less the pertinent fuel quantities used for energy purposes and so reported in the Energy Balance (TFR_i),
- The materials' C factors (CCF_i) and carbon-oxidation factors (COF_i),
- The relevant quantities of CO₂ subjected to further processing (R_{CO2}).

Following quality assurance, the IVA aggregates the data and communicates to the Federal Environment Agency the pertinent activity data, quantities of CO₂ subjected to further processing and process-related CO₂ emissions.

CO₂ emissions:

The IVA calculates the CO₂ emissions in keeping with Equation 3.3 in the 2006 IPCC Guidelines:

$$E_{CO2} = \sum (TFR_i * CCF_i * COF_i * 44/12)$$

The recovered quantity of CO₂, which is used in other production processes – such as urea production – is included in the reported emissions.

Emission factor for NO_x:

For the NO_x emission factor, the default emission factor given in the *CORINAIR Guidebook*, 1 kg / t NH₃, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.1.3 Uncertainties and time-series consistency (2.B.1)

Activity data:

Using a procedure in keeping with equation 6.3 in IPCC GPAUM, the IVA aggregates the uncertainties reported by the operators and communicates the result to the Federal Environment Agency.

The uncertainty for the activity data is ± 0.6 %. The uncertainty for the emissions is ± 1 %.

4.3.1.4 Source-specific quality assurance / control and verification (2.B.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.3.1.5 Source-specific recalculations (2.B.1)

No recalculations need to be carried out between the Resubmission 2010 and this year's report. Recalculations on the basis of the in-country review 2010 are presented in Chapter 10.5.2.7.

4.3.1.6 Source-specific planned improvements (2.B.1)

In keeping with the IPCC Guidelines, reporting is to be plant-specific, in accordance with the Tier 3 reporting standard, as of the 2010 report. Consequently, no further improvements are planned.

4.3.2 Chemical industry: Nitric acid production (2.B.2)

4.3.2.1 Source category description (2.B.2)

CRF 2.B.2										
Key source by level (l) / trend (t) / Tier 2 (T2)			Gas (key source)	1990 – contribution to total emissions			2009 – contribution to total emissions			Trend
			- / -							
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	NA	NA	NA	PS	D	NO	NO	NO
EF uncertainties in %						±5				
Distribution of uncertainties						N				
EF-determination method						T3				

The source category "*Chemical industry: nitric acid production*" is not a key source.

In production of nitric acid, nitrous oxide occurs in a secondary reaction. In Germany, there are currently seven nitric acid production plants.

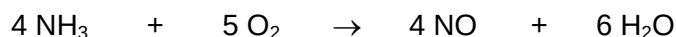
HNO₃ production occurs in two process stages:

- **Oxidation** of NH₃ to NO and
- **Conversion** of NO to NO₂ and **absorption** in H₂O.

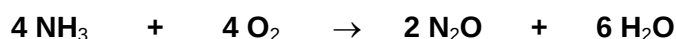
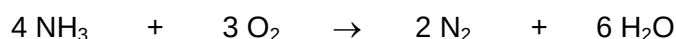
Details of the process are outlined below:

Catalytic oxidation of ammonia

A mixture of ammonia and air at a ratio of 1:9 is oxidised, in the presence of a platinum catalyst alloyed with rhodium and/or palladium, at a temperature of between 800 and 950 °C. The relevant reaction, according to the Oswald process, is as follows:



Simultaneously, nitrogen, nitrous oxide and water are formed by the following undesired secondary reactions:



All three oxidation reactions are exothermic. Heat may be recovered to produce steam for the process and for export to other plants and/or to preheat the residual gas. The reaction water is condensed in a cooling condenser, during the cooling of the reaction gases, and is then conveyed into the absorption column.

4.3.2.2 Methodological issues (2.B 2)

As of the 2010 reporting round, and in keeping with the IPCC Guidelines, nitric-acid production is now reported plant-specifically, in accordance with the Tier 3 standard. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data.

The operators of six plants transmit their data to the Industrieverband Agrar (IVA) industry association.

Plant operators report the following to the IVA:

- Nitric acid quantities produced (**activity data**),
- The EF,
- The N₂O emissions measured in the raw gas,
- Where emissions-reduction equipment is used, also the N₂O emissions measured in the emissions-reduced exhaust gas.

After carrying out quality assurance, the IVA aggregates the data, to protect confidentiality, and then transmits the so-aggregated data to the Federal Environment Agency (AD and EF). Pursuant to the IVA, the emissions-control technologies used include catalytic decomposition directly following ammonia combustion. The N₂O emissions are then calculated in keeping with the formula $EM = AD * EF$.

One company sends its data (AD, EF, N₂O emissions and information about any reduction equipment used) directly to the Federal Environment Agency. After carrying out quality assurance, the Federal Environment Agency then aggregates that company's data with the data provided by the IVA and enters the resulting so-aggregated data into the CSE emissions database.

Until 2006, production quantities correlated with the N₂O emissions. Subsequently, a decoupling of production quantities and N₂O emissions has become apparent that is due to use of emissions-reduction equipment.

NO_x emission factor:

For the NO_x emission factor, the default emission factor given in the *CORINAIR Guidebook*, 10 kg / t NH₃, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.2.3 Uncertainties and time-series consistency (2.B.2)

Activity data:

The activity-rate uncertainty, as provided by the operators, has been determined, as specified by the IVA / the Federal Environment Agency, in keeping with Equation 6.3 in IPCC GPAUM. The pertinent uncertainty is $\pm 1 \%$.

Emission factor:

For the N₂O emission factor, the operators give an uncertainty of $\pm 5 \%$.

4.3.2.4 Source-specific quality assurance / control and verification (2.B.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.3.2.5 Source-specific recalculations (2.B.2)

No recalculations need to be carried out between the Resubmission 2010 and this year's report. Recalculations on the basis of the in-country review 2010 are presented in Chapter 10.5.2.8.

4.3.2.6 Source-specific planned improvements (2.B.2)

In keeping with the IPCC Guidelines, reporting is to be plant-specific, in accordance with the Tier 3 reporting standard, as of the 2010 report. Consequently, no further improvements are planned.

4.3.3 Chemical industry: Adipic acid production (2.B.3)

4.3.3.1 Source category description (2.B.3)

CRF 2.B.3										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)		1990 – contribution to total emissions		2009 – contribution to total emissions		Trend		
Adipic Acid Production		l / t / T2		N ₂ O		1.54 %		0.91 %		-54.4 %
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	NO	NO	NO	D, PS	NE	NE	NO	NO
EF uncertainties in %						+/- 10%				
Distribution of uncertainties						N				
EF-determination method						CS				

The source category "Chemical industry: Adipic acid production" is a key source of N₂O emissions in terms of emissions level and trend.

The EF calculation for N₂O emissions from adipic acid production conforms to the Tier 3a method specified in the IPCC Guidelines for National Greenhouse Gas Inventories 2006.

On an industrial scale, adipic acid is produced via oxidation of a mixture of cyclohexanol and cyclohexanone (ratio: 93/7). Pursuant to IPCC-GPG (2000: Tab. 3.7, note a), only one facility, located in Japan, is presumed to use pure cyclohexanol (the EF there is 264 kg/t); at other facilities, adipic acid is produced from cyclohexanol, with varying amounts of ketone and nitric acid. In that reaction, considerable amounts of nitrous oxide (N₂O) are formed. Until the end of 1993, the two sole German producers emitted all of their nitrous oxide directly into the atmosphere. One producer has since patented, and put into operation, a system for thermal decomposition of nitrous oxide into nitrogen and oxygen. Decomposition takes place nearly completely. At the end of 1997, the other producer put a catalytic reactor system into operation that, in constant operation, achieves an N₂O-decomposition rate of 96-98 %. In March 2002, operations were begun with a plant, from another producer, that also uses thermal N₂O decomposition. Following initial technical problems, the system has been in constant operation since 2003. The overall fluctuations in decomposition rates – and, thus, the remaining emissions – are maintenance-related and production-dependent. In 2009, one producer commissioned a second, additional (i.e. redundant) thermal N₂O-decomposition

facility. Since that facility went into operation, N₂O-decomposition rates of over 99% have been achieved.

From 1990 to the present, production has more than doubled, as a result of growth in demand.

4.3.3.2 Methodological issues (2.B.3)

Until around the mid-1990s, producers provided data only on amounts produced. The IPCC default emission factors have been used to calculate nitrous oxide emissions for that period. For the subsequent period, in addition to reporting their production figures, producers also confidentially reported their N₂O emissions, along with necessary background information. This fact is highly significant with regard to the precision of the reported data; without data on technically unavoidable N₂O production, and – especially – without information as to the operating period of the relevant decomposition facilities, estimates of the reduction in nitrous oxide emissions would have been so imprecise that it would have been necessary to continue using the default EF.

The fluctuations in the emissions data are the result of disruptions of emissions-reduction systems (maintenance work, fire damage, other failures of system components) and of production increases.

4.3.3.3 Uncertainties and time-series consistency (2.B.3)

The uncertainties in time-series consistency have been eliminated, since all manufacturers now provide the relevant data. IPCC GL 2006 specifies uncertainties of +/- 0.05% for plants with thermal decomposition and of +/- 2.5% for plants with catalytic decomposition. According to producers' information, the uncertainties, regardless of what reduction process is used, lie within a range of +/- 5 to 5.9 %. The range for uncertainties relative to production quantities is given as +/-0.06 to 1 %. The EF is thus assumed to have an uncertainty of 5.9 %.

4.3.3.4 Source-specific quality assurance / control and verification (2.B.3)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Information provided by producers enjoys a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. The reported emissions and activity data have been reviewed by a Federal Environment Agency expert and compared with industry figures and figures from other publications.

4.3.3.5 Source-specific recalculations (2.B.3)

No recalculations are required.

4.3.3.6 Source-specific planned improvements (2.B.3)

No improvements are planned at present.

4.3.4 Chemical industry: Carbide production (2.B.4)

4.3.4.1 Source category description (2.B.4)

CRF 2.B.4					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
	- / -				

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor, CaC ₂	PS	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emission factor, SiC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %	±10									
Distribution of uncertainties	N									
EF-determination method	PS									

The source category "Chemical industry: carbide production" is not a key source.

During the reunification period, calcium carbide production took place primarily in the new German Länder. A short time later, production there was discontinued, while only one producer remained in the old German Länder. In the period under consideration, this producer cut his production by about half.

According to the responsible specialised association within the VCI, no silicon carbide has been produced in Germany since 1993. Emissions from this sector thus no longer occur.

4.3.4.2 Methodological issues (2.B.4)

Activity data:

Since Germany has only one producer, the relevant data must be kept confidential. The only published data consists of that for amounts produced in the former GDR. That data was published, until 1989, by that country's central statistical authority. Those figures were used, in combination with existing estimates for 1991 and 1992, to interpolate production in the new German Länder in 1990.

Emission factor:

The stoichiometric emission factor for CO₂ is 688 kg per tonne of calcium carbide (44 g mol⁻¹ / 64 g mol⁻¹). Until 1992, this emission factor was used for production in the new German Länder.

In covered furnaces, producers collect all of the carbon monoxide produced in the process and recycle it for further use. Following such use for energy recovery – i.e. following its combustion to produce carbon dioxide – it serves as an auxiliary substance for production of lime nitrogen and secondary products. Reactions in these processes yield carbon dioxide in mineral form, as black chalk. In this form, it is used in agriculture.

As a result, to this day production in the old German Länder achieves a substantially lower emission factor for carbon dioxide from calcium carbide production.

Upon request, the relevant producer provides the Federal Environment Agency with data on the degree of reduction achieved – and, thus, on the emission factor involved – and on amounts produced. The total emissions are calculated as the product of activity data and emission factor.

4.3.4.3 Uncertainties and time-series consistency (2.B.4)

Consistency is not complete, due to the described need to estimate production amounts in the new German Länder.

The uncertainties relative to the data provided by the producer are considered slight overall. The assumed reduction rate of about 80% should be seen as an average value for the time period in question. As a result of use of green petrol coke, the composition of gas in carbide furnaces has changed, and this keeps the reduction rate from climbing still higher.

4.3.4.4 Source-specific quality assurance / control and verification (2.B.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Producers' relevant figures enjoy a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. No calculations for verification could be carried out. It may be noted, however, that some of the figures have also been provided to licensing authorities and thus are considered trustworthy.

4.3.4.5 Source-specific recalculations (2.B.4)

No recalculations are required.

4.3.4.6 Source-specific planned improvements (2.B.4)

No improvements are planned at present.

4.3.5 Chemical industry – other: Emissions from other production processes (2.B.5)

4.3.5.1 Source category description (2.B.5)

CRF 2.B.5					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
Other	l / t / T2	CO ₂	0.56 %	0.93 %	+27.0 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF) carbon black	D	CS	NO	NO	NO	NO	NO	D	NO	D
Emission factor (EF) ethylene, styrene	NO	D	NO	NO	NO	NO	NO	NO	CS	NO
Emission factor (EF) methanol, 1,2-dichloroethane	CS	D	NO	NO	NO	NO	NO	NO	NO	NO
Emission factor (EF) transformation processes, coke burn-off for catalyst regeneration, in refineries	CS	NO	NO	NO	NO	NO				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category "Chemical industry: Emissions from other production processes" is a key source of CO₂ emissions in terms of both emissions level and trend.

A range of different chemical production processes are potential sources of CO₂, CH₄ and NMVOC emissions. These processes include production of carbon black, ethylene (ethene), ethylene dichloride (1,2-dichloroethane), styrene and methanol, and, in refineries, coke burn-off for catalyst regeneration.

In refinery operations, coke burn-off for catalyst regeneration occurs in catalytic cracking plants in which desulphurised vacuum and other gasoil distillates are broken down at temperatures of about 550°C, in a water-vapour atmosphere, into refinery gas, liquid gases, gasoline fractions and medium distillates. CO₂ emissions occur in catalyst regeneration in the reforming process, which is designed to increase octane levels in raw gasoline and to generate hydrocarbon aromates via isomerisation and ring formation. The fluid catalytic cracking (FCC) process is now the leading process used for this purpose. During cracking reactions in an FCC reactor, coke is deposited on the catalyst. That coke is then burned off, via air input, in the regenerator. In the reforming process, platinum is used as the catalyst, in combination with rhenium and tin, and applied to acidic aluminium oxide. The catalyst grows ineffective as a result of process-related deposition of coke on its active centres. In catalyst regeneration, coke is burned-off to restore proper catalytic function. CO₂ is released in these combustion processes.

Since the early 1990s, German caprolactam producers have used thermal waste-gas treatment in their production operations. N₂O emissions no longer occur in those operations.

4.3.5.2 Methodological issues (2.B.5)

CO₂ emissions

In the 2006 reporting year, reporting on CO₂ emissions into the atmosphere was added for the sources carbon-black production, methanol production, transformation processes and coke burn-off for catalyst regeneration in refineries. In the 2011 reporting year, reporting on such emissions was added for ethylene oxide.

For CO₂ from carbon-black production, the default emission factor from the IPCC Guidelines 2006 is used (Table 3.23, Furnace black process (default process), primary feedstock). The industry was unable to confirm the previously used EF, which was obtained via a research project. As of the 2011 report, the default EF of the IPCC-GL 2006 is used for methanol and ethylene oxide.

With regard to refineries, only catalyst regeneration is taken into account. Reviews to date indicate that other emissions sources from refineries (heavy-oil gasification, calcination and hydrogen production) are already covered as part of refineries' own consumption (cf. Chapter 3.2.7).

CH₄ emission factors

The international guidelines give very little attention to this source category. The IPCC Guidelines list as potential sources – without any claim to completeness – production of carbon black, ethylene, dichloroethylene (1,2-dichloroethane), styrene and methanol. The Guidelines list emission factors for the processes that were identified in studies from 1987 and 1988; those IPCC default EF (1996 Guidelines) are listed in Table 86 below.

Table 86: IPCC default emission factors for CH₄ from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2 - dichloroethane ³⁸	Methanol
[kg CH ₄ /t]				
0.06 (with thermal post-combustion)				
28.7 (without thermal treatment)	4	1	0.4	2

The IPCC Good Practice Guidance does not discuss this subject further.

Pursuant to Point 5.2.5 of the TA Luft (Technical Instructions on Air Quality Control), German plants subject to the TA Luft must meet a standard of 50 mg/m³ (total carbon) for total mass concentration of organic substances (NMVOC and CH₄, but not including organic substances in dust form). The current state of the art provides for thermal post-combustion of volatile organic substances from plants for production of primary organic chemicals.

In keeping with these technical standards, the three German producers of carbon black report an emission factor of 0.027 kg methane per tonne of carbon black. Since relevant technology has been in service since the 1970s, this EF is rounded off to 0.03 kg/t and applied to the entire time series.

As to the other four products, the largest German producer reports that no further methane emissions occur in those areas, thanks to thermal post-combustion. This technology has been in service since the 1980s, and thus the pertinent emission factors can be applied to the entire time series.

Table 87: National emission factors for CH₄ from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2-dichloroethane ³⁹	Methanol
[kg CH ₄ /t]				
0,03	0	0	0	0

Emission factors for NMVOC, CO and SO₂

For pollutants other than the methane considered above, the emission factors listed in Table 88 were used for Germany.

³⁸ Remark: In this IPCC table (Workbook p. 2.22, Tab. 2-9 and Reference Manual p. 2.23, Tab. 2-10), dichloroethylene has been replaced with ethylene dichloride (1,2-dichloroethane). This seems appropriate, since the relevant subsequent tables (2-10 and 2-11) list only "1,2, dichloroethane" and since the source listed by the IPCC Reference Manual on p. 2.67, Stockton et al., p. 49, also speaks of the substance "ethylene dichloride"

³⁹ Remark: In this IPCC table (Workbook p. 2.22, Tab. 2-9 and Reference Manual p. 2.23, Tab. 2-10), dichloroethylene has been replaced with ethylene dichloride (1,2-dichloroethane). This seems appropriate, since the relevant subsequent tables (2-10 and 2-11) list only "1,2, dichloroethane" and since the source listed by the IPCC Reference Manual on p. 2.67, Stockton et al., p. 49, also speaks of the substance "ethylene dichloride"

Table 88: Emission factors used in Germany for other pollutants

	Carbon black [kg CO / t]	Carbon black [kg SO ₂ /t] ⁴⁰	Ethylene [kg NMVOC / t]	1,2 - dichloroethane [kg NMVOC / t]	Polystyrene [kg NMVOC / t]	Styrene [kg NMVOC / t]
1990	4.8/ 5	19.5 / ⁽⁴¹⁾	5	2.5	1	0.02
1991	4.6/ 5	19 / 20	5	2.5	1	0.02
1992	4.4/ 5	18.5 / 20	5	2.5	1	0.02
1993	4.2	18	5	2.5	1	0.02
1994	4	17.5	5	2.5	1	0.02
1995	3.75	17	0.4	0.03	0.6	0.02
1996	3.5	16	0.3	0.022	0.4	0.02
1997	3.25	15	0.3	0.022	0.4	0.02
1998	3	14	0.25	0.018	0.32	0.02
1999	2.9	13.4	0.25	0.018	0.32	0.02
2000	2.8	12.8	0.2	0.015	0.27	0.02
2001	2.7	12.54	0.2	0.015	0.27	0.02
2002	2.65	12.28	0.2	0.015	0.27	0.02
2003	2.6	12.0	0.2	0.015	0.27	0.02
2004	2.55	11.7	0.2	0.015	0.27	0.02
2005	2.5	11.5	0.2	0.015	0.27	0.02
2006	2.5	11.2	0.2	0.015	0.27	0.02
2007	2.5	10.9	0.2	0.015	0.27	0.02
2008	2.5	10.6	0.2	0.015	0.27	0.02
2009	2.5	10.3	0.2	0.015	0.27	0.02

The NMVOC emission factors for polystyrene were taken from the European Commission (EC, 2006a, BAT Reference Document (BREF), Production of Polymers), while for other products figures of German producers were used (these figures are available as confidential data). The default factors were used until 1994. The EF figures for CO and SO₂, for production of carbon black, are based on the BREF Large Volume Inorganic Chemicals - LVIC – S (EC, 2007) and are identical with the default values presented in the 2008 CORINAIR manual (first order draft).

Activity data

The production statistics of the Federal Statistical Office include the following products (Table 89).

Table 89: Reporting numbers (Meldenummern) from production statistics

Line	Polystyrene	Methanol	1,2 - dichloroethane	Carbon black	Ethylene	Styrene
through 1994	4414 42	4232 11	4228 22	4113 70	4221 11	4224 60
since 1995	2416 20 350 and ...390	2414 22 100	2414 13 530	2413 11 300	2414 11 300	2414 12 500
since 2009				2013 21 300		

The figure for carbon-black production in the new German Länder in 1990 was taken from the Statistical Yearbook (Statistisches Jahrbuch) for the Federal Republic of Germany (*FEDERAL STATISTICAL OFFICE*, 1992: p. 234); the figures for 1991 and 1992 were estimated, due to confidentiality requirements. The other data for carbon-black production as of 1990 were obtained from the Federal Statistical Office (*FEDERAL STATISTICAL OFFICE*,

⁴⁰ Where two EF are listed, the second figure refers to the new German Länder.

⁴¹ No EF is listed for the new German Länder, since these SO₂ emissions can be taken account of only as a lump sum.

Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe ("manufacturing industry; production in the manufacturing industry").

4.3.5.3 Uncertainties and time-series consistency (2.B.5)

The emission factors for ethylene, methanol, 1,2-dichloroethane and styrene are based on evaluations carried out by German producers. In the 1980s, thermal post-combustion was introduced on a large scale. As a result, emissions of organic substances from German plants are low enough to be neglected. The uncertainties cannot be estimated, however. The new emission factors are valid for the entire time series. Fluctuations in the activity data have occurred over the period under consideration. The reasons for this are unknown. Since the production-quantity data – apart from a few insignificant estimates – have come from a trustworthy source, the pertinent uncertainties may be considered small. Corrections to producers' figures might be made within a three-year period, however. In spite of the survey changes that have occurred within the period under consideration, the data are considered to be consistent.

4.3.5.4 Source-specific quality assurance / control and verification (2.B.5)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.3.5.5 Source-specific recalculations (2.B.5)

For methanol, the existing CO₂-emissions figure was replaced with the default CO₂ emission factor of 670 kg CO₂/t given in IPCC-GL 2006, since the existing data did not seem plausible to a reviewing expert, were based on a single (one-time) survey and were not available on a long-term basis.

Table 90: Recalculation of CO₂ emissions from methanol production (2.B.5)

2 B 5, Other, Methanol	Gas	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Resubmission 2010	CO ₂	Gg	830.000	1,360.000	1,430.000	1,330.000	1,590.000	1,580.000	1,710.000	1,560.000	1,770.000	1,700.000
Submission 2011	CO ₂	Gg	848.380	825.132	864.966	805.467	963.679	955.283	1,036.462	944.600	1,069.493	1,027.186
Difference	CO ₂	Gg	+18.380	-534.868	-565.034	-524.533	-626.321	-624.717	-673.538	-615.401	-700.507	-672.814
2 B 5, Other, Methanol	Gas	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Resubmission 2010	CO ₂	Gg	2,090.000	2,130.000	2,040.000	2,220.000	2,351.429	2,351.429	2,351.429	2,351.429	2,351.429	
Submission 2011	CO ₂	Gg	1,263.907	1,287.526	1,235.001	1,345.410	1,220.919	1,313.804	1,399.775	1,356.702	1,125.416	1,032.869
Difference	CO ₂	Gg	-826.093	-842.474	-804.999	-874.590	-1,130.510	-1,037.625	-951.654	-994.727	-1,226.013	

4.3.5.6 Source-specific planned improvements (2.B.5)

No improvements are planned at present.

4.4 Metal production (2.C)

Source category 2.C is sub-divided into sub-categories 2.C.1 through 2.C.5. In the CSE emissions database, sub-category Iron and steel production (2.C.1) includes sinter production, pig-iron production, iron and steel production and tempered castings. Production of ferroalloys (2.C.2) is listed directly as such in the CSE. Aluminium production (2.C.3) is sub-divided into primary aluminium and resmelted aluminium. Use of SF₆ in aluminium and magnesium production (2.C.4) is not further sub-divided. In the CSE, sub-category Other (2.C.5) includes lead production, thermal galvanisation, copper production and zinc production.

4.4.1 Metal production: Iron and steel production (2.C.1)

4.4.1.1 Source category description (2.C.1)

CRF 2.C.1										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend					
Steel (integrated production)	l / t / T2	CO ₂	1.86 %	1.24 %	-48.6 %					
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	CS	CS	CS
EF uncertainties in %	-	-	-	-	-	-				
Distribution of uncertainties	-	-	-	-	-	-				
EF-determination method	T2	-	-	-	-	-				

The source category *Iron and steel production* is a key source of CO₂ emissions in terms of emissions level and trend.

In 2009, a total of 21.3 million t of raw steel, from ore, was produced in Germany in six integrated steel works. Electric steel production amounted to 11.3 million t.

4.4.1.2 Methodological issues (2.C.1)

This sector comprises process-related emissions from primary steel production (via blast furnaces and oxygen-steel plants) and from electric steel plants.

Other structural elements in this source category (foundries: iron and steel casting (including malleable casting); steel production: rolled-steel production; steel-pig-iron production) are used for calculation of other pollutant emissions (not greenhouse-gas emissions).

Process-related CO₂ emissions from primary steel production in integrated smelters result primarily from use of reducing agents in blast furnaces. CO₂ emissions from limestone inputs in sinter plants and in pig-iron production, and CO₂ emissions from electrode consumption in electric steel production, are added to process-related emissions in sector 2.C.1.

Method for calculating the CO₂ emissions resulting from use of reducing agents in blast furnaces

Until the NIR 2010, CO₂ emissions from primary steel production were determined via the input quantities of reducing agents; those, in turn, were taken from the Energy Balance. Via use of a theoretical factor for the reducing-agent quantities required for an ideal blast-furnace process, a majority of the determined emissions were assigned to source category 2.C.1. The remaining emissions from use of reducing agents were reported under 1.A.2.a. That approach was in keeping with the allocation method for the 1st trading period of greenhouse-gas-emissions trading. Since that special method is now no longer used in emissions trading, it no longer seemed suitable for the inventory. The methods change carried out with the present reporting round will help enhance transparency and comparability in the reports.

Pursuant to the IPCC Guidelines, the CO₂ emissions in source category 2.C.1 are to be determined via a carbon balance. The reason for this requirement is that virtually all of the carbon used for primary steel production is subsequently released into the atmosphere, as CO₂, in later energy-related use, or in flaring, of the top gas that forms in the blast furnace or of the converter gas that forms in the oxygen steel converter. The share of carbon that remains in produced steel, or in that portion of pig iron that is not processed into steel, is not relevant for primary steel production in Germany⁴².

There are thus two ways of calculating the CO₂ emissions resulting from use of reducing agents: either via the quantity of reducing agents used (carbon input) or via the production of top gas and converter gas (carbon output). Relevant statistical information is available, at the national level, for both approaches. The two approaches produce different emissions results, however; the emissions as calculated via the quantities of top gas / converter gas used are higher, throughout, than those that result via calculation with quantities of reducing agents. That statistical difference, which has been growing in the years since 2003, cannot be logically explained. In keeping with the principle of conservative estimation, it was decided to use quantities of top gas and converter gas as the basis for the emissions calculation. That was also the procedure recommended by the Climate Secretariat's expert commission, which reviewed Germany's 2010 inventory report in September 2010.

Only part of all energy-related use of top gas and converter gas is found in source category 2.C.1. Such gas is used for other process combustion in the iron and steel industry (1.A.2.a); in coking plants, for bottom heating of coking furnaces (1.A.1.c); and for electricity generation in public power stations (1.A.1.a) and industrial power stations (1.A.2.f). The German Energy Balance provides information relative to top-gas and converter-gas consumption in all of the aforementioned source categories. Consequently, the CO₂ emissions resulting from reducing-agent inputs for primary steel production are divided among all source categories in which top gas and converter gas are burned and, thus, CO₂ is actually emitted (cf. the following figure).

⁴² The average carbon fraction in the more than 2000 types of steel produced in Germany is normally considerably smaller than 2%. It is not recorded statistically, however. In any case, the pertinent deduction of non-energy-related carbon is extremely small (<1.5 %) in comparison to the total CO₂ emissions from primary steel production. Since only about 3% of the pig iron produced in Germany is not processed into oxygen steel, the pertinent deduction of non-energy-related carbon is also marginal (ca. 0.1%).

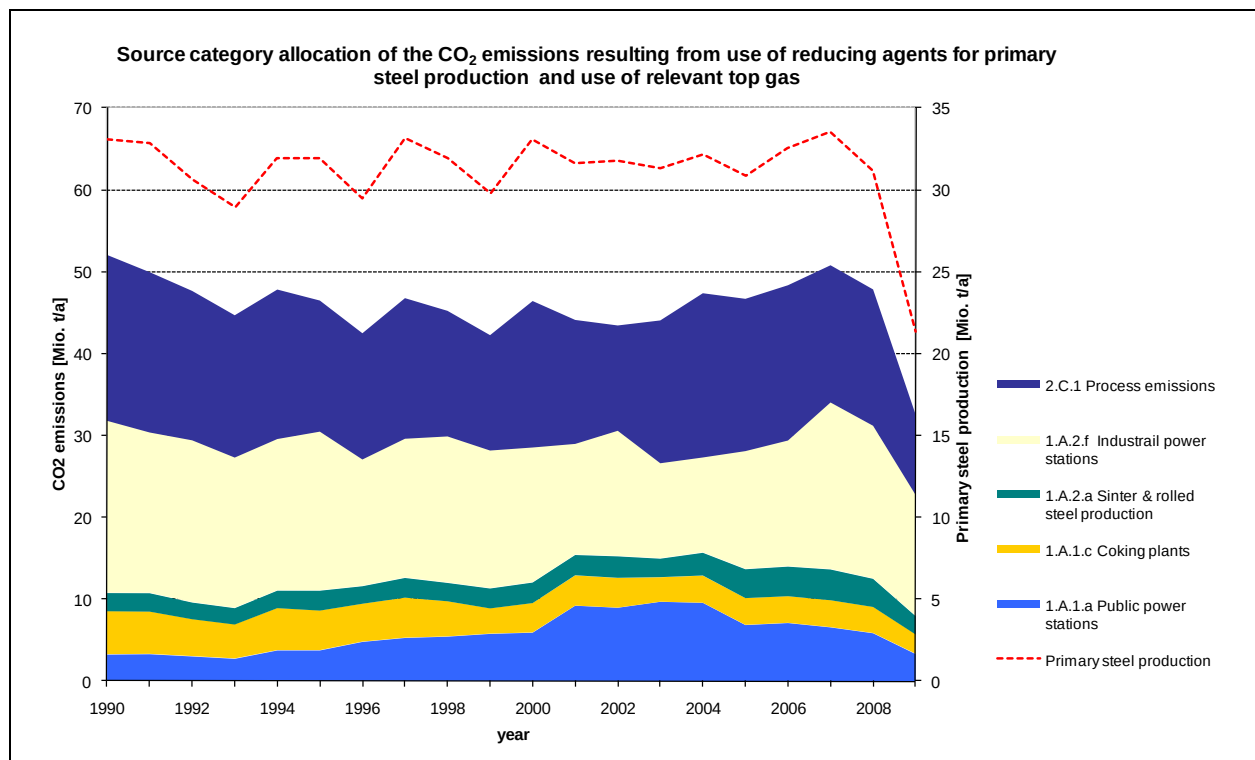


Figure 41: Chronological trend and source-category allocation of the CO₂ emissions resulting from use of reducing agents for primary steel production and from use of top gas

The sum of the CO₂ emissions shown shows good correlation with the activity data reported for primary steel production (cf. the broken red line). Annual fluctuations in the individual source categories are probably due to changes in allocation of individual plants within official statistics. Such fluctuations have practically no impact on the total sum of reported emissions, however.

Table 91: CO₂ emissions from primary steel production (including top-gas use)

Mt CO ₂	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1.A.1.a Public power stations	3.236	3.283	3.008	2.719	3.744	3.745	4.796	5.282	5.440	5.782
1.A.1.c Coking plants	5.328	5.234	4.579	4.220	5.201	4.899	4.686	4.947	4.342	3.131
1.A.2.a Sinter and rolled-steel production	2.223	2.251	2.041	2.001	2.136	2.433	2.142	2.408	2.245	2.433
1.A.2.f Industry power stations	21.043	19.639	19.823	18.403	18.526	19.431	15.489	17.005	17.896	16.857
2.C.1 Process emissions	20.245	19.566	18.233	17.369	18.244	16.000	15.407	17.159	15.330	14.082
Mt CO ₂	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1.A.1.a Public power stations	5.930	9.243	8.990	9.723	9.597	6.866	7.112	6.578	5.858	3.300
1.A.1.c Coking plants	3.636	3.725	3.668	3.015	3.341	3.308	3.293	3.332	3.230	2.421
1.A.2.a Sinter and rolled-steel production	2.508	2.476	2.618	2.255	2.776	3.526	3.616	3.761	3.441	2.242
1.A.2.f Industry power stations	16.500	13.567	15.337	11.657	11.643	14.432	15.406	20.395	18.698	14.814
2.C.1 Process emissions	17.879	15.131	12.856	17.432	20.046	18.587	18.953	16.749	16.639	9.807

In the iron and steel industry, secondary fuels are used only in pig iron production in blast furnaces. To date, these materials have not yet been included in national statistics and the Energy Balance. For this reason, the data used consisted of figures provided by the Wirtschaftsvereinigung Stahl steel-industry association. Since the secondary fuels are used solely as substitute reducing agents, in place of coke, the CO₂ emissions resulting from their

use are also included in the CO₂ emissions determined via use of top gas and converter gas and do not have to be calculated separately.

Determination of CO₂ emissions from limestone inputs in pig iron production

CO₂ emissions from limestone use are determined in accordance with Tier 1 (UBA 2006, FKZ 20541217/02). The steel industry uses limestone (CaCO₃) only in processing of iron ores (sintering plants) and in pig iron production in blast furnaces. In the oxygen steel and electric steel processes, already burnt lime for steel-mill applications (CaO) is used as a slag former; the CO₂ emissions released in producing that burnt lime are thus already reported under 2.A.2. Until 2004, limestone inputs in sinter and pig iron production were published as part of iron and steel statistics (*FEDERAL STATISTICAL OFFICE* Fachserie 4, Reihe 8.1). Since then, they have to be calculated from the production quantities of sinter and pig iron reported by the association, via specific input factors (kg of limestone per tonne of sinter or pig iron). Multiplying the activity data for limestone inputs by the stoichiometric emission factor for limestone produces the CO₂-emissions figures given in Table 92.

Table 92: Limestone inputs and resulting CO₂ emissions in sinter and pig iron production

Year	Limestone input [t/a]		CO ₂ emissions [t/a]		
	Pig iron	Sinter	Pig iron	Sinter	Total
1990	755,737	4,680,775	332,524	2,059,541	2,392,065
1991	757,000	4,532,000	333,080	1,994,080	2,327,160
1992	666,000	4,198,000	293,040	1,847,120	2,140,160
1993	627,000	3,891,000	275,880	1,712,040	1,987,920
1994	733,000	4,173,153	322,520	1,836,187	2,158,707
1995	751,000	4,600,000	330,440	2,024,000	2,354,440
1996	686,000	4,350,000	301,840	1,914,000	2,215,840
1997	629,000	4,471,000	276,760	1,967,240	2,244,000
1998	677,000	4,588,000	297,880	2,018,720	2,316,600
1999	817,000	4,144,000	359,480	1,823,360	2,182,840
2000	924,000	4,273,000	406,560	1,880,120	2,286,680
2001	866,000	4,136,000	381,040	1,819,840	2,200,880
2002	831,000	3,940,000	365,640	1,733,600	2,099,240
2003	832,525	4,046,711	366,311	1,780,553	2,146,864
2004	847,689	4,209,871	372,983	1,852,343	2,225,326
2005	787,724	4,306,067	346,599	1,894,669	2,241,268
2006	822,920	4,410,408	362,085	1,940,580	2,302,664
2007	840,868	4,608,067	369,982	2,027,549	2,397,531
2008	790,216	4,541,174	347,695	1,998,117	2,345,812
2009	547,680	3,496,405	240,979	1,538,418	1,779,397

Source: until 2004: calculations in the Kalksteinbilanz ("limestone balance" project (UBA 2006, FKZ 20541217/02),
as of 2005: Calculation via the product-specific factors determined in the project mentioned above

Determination of CO₂ emissions from electrode consumption in electrical steel production

In electric steel production, CO₂ emissions occur directly via consumption of graphite electrodes. These emissions must also be allocated to process-related CO₂ emissions for steel production. They are calculated from the quantity of produced electric steel, via an emission factor that was newly determined in 2009 (7.4 kg/t) and that is based on the specific electrode consumption per tonne of electric steel (2.06 kg/t), its carbon content (98%) and the relevant stoichiometric factor (3.667 t CO₂/t C). The contribution from electrode

combustion in electric steel production, at about 0.2% of total CO₂ emissions in iron and steel production, is insignificant.

Determination of the total CO₂ emissions from iron and steel production to be reported under 2.C.1

The total process-related emissions to be reported under 2.C.1 consist of the following:

1. The CO₂ emissions resulting from use of reducing agents in primary steel production, where the relevant top gas and converter gas is not used in other source categories and thus reported under other categories as CO₂ emissions
2. The CO₂ emissions from limestone inputs in pig iron production, and
3. The CO₂ emissions from electrode consumption in electrical steel production

The relevant so-determined emissions quantities are shown in Table 96.

Table 93: Total process-related emissions to be reported under 2.C.1

	CO ₂ emissions from use of reducing agents, for uses not reported in other source categories	CO ₂ emissions from limestone input	CO ₂ emissions from electrode consumption	2.C.1 total
Year	[t/a]	[t/a]	[t/a]	[t/a]
1990	20,244,570	2,392,065	75,242	22,711,877
1991	19,566,299	2,327,160	68,464	21,961,923
1992	18,233,163	2,140,160	64,358	20,437,681
1993	17,368,898	1,987,920	59,840	19,416,658
1994	18,244,329	2,158,707	65,783	20,468,820
1995	15,999,678	2,354,440	74,794	18,428,912
1996	15,407,293	2,215,840	76,291	17,699,424
1997	17,159,145	2,244,000	87,552	19,490,696
1998	15,330,371	2,316,600	89,196	17,736,167
1999	14,081,926	2,182,840	90,457	16,355,223
2000	17,878,539	2,286,680	98,251	20,263,471
2001	15,130,790	2,200,880	96,961	17,428,630
2002	12,856,088	2,099,240	97,381	15,052,709
2003	17,432,279	2,146,864	99,048	19,678,190
2004	20,045,595	2,225,326	104,984	22,375,905
2005	18,587,293	2,241,268	100,780	20,929,341
2006	18,952,642	2,302,664	108,206	21,363,512
2007	16,749,314	2,397,531	110,721	19,257,566
2008	16,638,663	2,345,812	107,948	19,092,423
2009	9,806,506	1,779,397	83,590	11,669,493

4.4.1.3 Uncertainties and time-series consistency (2.C.1)

The time series is consistent, since the activity data have been determined for all plants and since the same method has been used to determine the emissions for all years concerned.

A discontinuity in methods is seen in the case of CO₂ emissions from limestone inputs, from 2004 to 2005; it results from the absence of the data source used until 2004. The time-series trend seems plausible in spite of this discontinuity. In keeping with the required calculation, the uncertainty for the activity data here is $\pm 10\%$.

The uncertainty for the emission factor for electrode consumption is $\pm 3\%$, while the uncertainty for the other data is $\pm 5\%$, since it is based solely on inaccuracies in measurement and analysis.

4.4.1.4 Source-specific quality assurance / control and verification (2.C.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The Single National Entity's additional quality assurance remains to be carried out.

Determining emissions in source categories 1.A.2.a and 2.C.1 is a complex task, since the Energy Balance, emissions reporting, emissions trading and association statistics differ widely in terms of their underlying methods. In the interest of data quality assurance, regular experts' discussions are carried out for the purpose of comparing and evaluating data. As a result of the methodological differences, plausibility checks of the determined emissions quantities, using data of the German emissions trading authority, are possible – if at all – only at a highly aggregated level.

4.4.1.5 Source-specific recalculations (2.C.1)

As a result of the change in the method of calculating the CO₂ emissions resulting from use of reducing agents in primary steel production, and because a new emission factor has been determined for electrode consumption in electric steel production, a recalculation was carried out for the entire time series as of 1990.

Due to the change in the method for calculating CO₂ emissions from use of reducing agents in primary steel production, the emissions reported under 2.C.1 have decreased, by about 1/2 to 2/3, with respect to the Resubmission of the NIR in 2010 (cf. Table 94). With respect to the overall level of German GG emissions, this does not represent a change with regard to the 2010 inventory Resubmission, because that Resubmission already included the (higher) CO₂ emissions calculated via figures for top gas and converter gas production. With the new calculation method, the CO₂ emissions resulting from use of reducing agents are simply distributed differently. They are also distributed among additional source categories – namely, those in which the top gas and converter gas formed in primary steel production is burned, and thus the relevant CO₂ is actually emitted. The precise distribution of those emissions, among the source categories 1.A.1.a, 1.A.1.c, 1.A.2.a, 1.A.2.f and 2.C.1 (Figure 41) is described in Chapter 4.4.1.2.

The change with respect to electric steel production affects only the years as of 1993, since the previously used factors for the years as of 1993 were lower than the newly determined factor for the year 2008. Since it did not seem plausible that electrode consumption could have been lower in the period 1993-2007 than it was in 2008, the new factor is used for all years as of 2003. In all relevant years, that change (cf. column 8 in Table 94 with respect to column 4) leads only to a marginal increase of total process-related CO₂ emissions from iron and steel production, however (maximum of 0.2 %).

Table 94 Recalculation of process-related CO₂ emissions, from iron and steel production, reported under 2.C.1

Year	NIR 2010				NIR 2011				Änderung	
	CO ₂ from use of reducing agents	CO ₂ from limestone use	CO ₂ from electrode consumption	2.C.1 total	CO ₂ from top gas	CO ₂ from limestone use	CO ₂ from electrode consumption	2.C.1 total	absolute figure	relative
	[Gg/a]	[Gg/a]	[Gg/a]	[Gg/a]	[Gg/a]	[Gg/a]	[Gg/a]	[Gg/a]	[Gg/a]	[%]
1990	45,859	2,392	75	48,326	20,245	2,392	75	22,712	-25,614	-53%
1991	43,928	2,327	69	46,324	19,566	2,327	69	21,962	-24,362	-53%
1992	40,687	2,140	64	42,891	18,233	2,140	64	20,438	-22,454	-52%
1993	38,571	1,988	57	40,616	17,369	1,988	60	19,417	-21,199	-52%
1994	41,713	2,159	63	43,934	18,244	2,159	66	20,469	-23,465	-53%
1995	41,704	2,354	67	44,125	16,000	2,354	75	18,429	-25,697	-58%
1996	38,487	2,216	65	40,768	15,407	2,216	76	17,699	-23,069	-57%
1997	43,306	2,244	71	45,621	17,159	2,244	88	19,491	-26,130	-57%
1998	41,759	2,317	68	44,143	15,330	2,317	89	17,736	-26,407	-60%
1999	38,942	2,183	65	41,190	14,082	2,183	91	16,355	-24,835	-60%
2000	43,199	2,287	67	45,553	17,879	2,287	98	20,264	-25,289	-56%
2001	41,372	2,201	63	43,635	15,131	2,201	97	17,429	-26,207	-60%
2002	41,574	2,099	63	43,737	12,856	2,099	97	15,053	-28,684	-66%
2003	40,958	2,147	64	43,168	17,432	2,147	99	19,678	-23,490	-54%
2004	42,003	2,225	68	44,296	20,046	2,225	105	22,376	-21,920	-49%
2005	40,330	2,241	65	42,637	18,587	2,241	101	20,929	-21,707	-51%
2006	42,543	2,303	70	44,916	18,953	2,303	108	21,364	-23,552	-52%
2007	43,830	2,398	72	46,299	16,749	2,398	111	19,258	-27,042	-58%
2008	40,769	2,346	70	43,185	16,639	2,346	108	19,092	-24,093	-56%

4.4.1.6 Source-specific planned improvements (2.C.1)

The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.

4.4.2 Metal production: Ferroalloys production (2.C.2)

4.4.2.1 Source category description (2.C.2)

CRF 2.C.2											
Key source by level (l) / trend (t) / Tier 2 (T2)			Gas (key source)		1990 – contribution to total emissions			2009 – contribution to total emissions			Trend
			- / -								
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂	
Emission factor (EF)	CS	NO	NO	NO	NO	NO	NE	NE	NE	NE	
EF uncertainties in %	-	-	-	-	-	-					
Distribution of uncertainties	-	-	-	-	-	-					
EF-determination method	T2	-	-	-	-	-					

The source category *Ferroalloys production* is not a key source. Ferroalloys are aggregates that are alloyed with steel. There are five ferroalloy producers in Germany; ferrochromium, ferrosilicon and silicon metal are each produced by only one company, and other ferroalloys are produced only in small quantities. According to data of the US Geological Survey, in 2007, 72,000 t of ferroalloys were produced in Germany in 2007. The only process in use since 1995 is the electric arc process, a process that releases only small amounts of process-related CO₂, with such releases occurring in electrode consumption.

Until 1995, the blast-furnace process, which produces relatively higher CO₂ emissions, was used to some extent.

4.4.2.2 Methodological issues (2.C.2)

The emission factors for the aforementioned two processes (blast-furnace and electric-arc processes) were determined in the research project "NEW CO₂" ("NEU-CO₂") (FKZ 203 41 253/02).

For the period since 1994, the activity data is determined via data of the US Geological Survey (USGS). The most current data date from 2007. Those figures are also used for the years 2008 and 2009.

4.4.2.3 Uncertainties and time-series consistency (2.C.2)

The activity data provided by the US Geological Survey (USGS) are based partly on estimates and thus are subject to relatively large uncertainties.

For the period 2001 – 2006, data of the Federal Statistical Office (DESTATIS) on sales of ferroalloys are available. Those data are lower, by a factor of 0.7, than the production data of the USGS, however. In the interest of the consistency of the time series, the USGS data have thus also been used for those years.

The considerable decrease in the CO₂ emission factor that took place from 1994 to 1995 does not represent any inconsistency; it is the result of the change in the production process.

4.4.2.4 Source-specific quality assurance / control and verification (2.C.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The activity data used, which come from the USGS, have been verified with the help of the DESTATIS figures (see above). The emissions figures were not compared with corresponding figures from other data sources for Germany, because no other data sources for emissions in category 2.C.2 are known.

4.4.2.5 Source-specific recalculations (2.C.2)

Because data of the US Geological Survey (USGS) are being used for the first time, the CO₂ emissions for the years as of 1994 were recalculated.

Table 95: Source-specific recalculations - Ferroalloys production (2.C.2)

2.C.2 Ferroalloys production	Units	1994	2000	2006	2007	2008	2009
Resubmission 2011	[Gg CO ₂ -equiv.]	5.17	2.75	2.75	2.75	2.75	2.75
Submission 2012		9.66	8.54	8.49	7.92	7.92	7.92
Absolute difference		4.49	5.79	5.74	5.17	5.17	5.17
Relative difference	[%]	87%	210%	209%	188%	188%	188%

4.4.2.6 Source-specific planned improvements (2.C.2)

No improvements are planned at present.

4.4.3 Metal production: Primary aluminium production (2.C.3)

4.4.3.1 Source category description (2.C.3)

CRF 2.C.3										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions			2009 – contribution to total emissions			Trend	
Aluminium Produktion		- / t	PFC			0.13 %			0.03 %	
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	CS	NE	NO	CS	NO	NO	NE	CS	NO	CS
EF uncertainties in %	15			15						
Distribution of uncertainties	N			N						
EF-determination method	T3			T3						

The source category *Primary aluminium production* is a key source of PFC emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-84.1 %), and thus an extremely low emissions level has been attained (in 2009, emissions amounted to 7.3 % of the contribution of the smallest key source identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key sources.

In Germany, aluminium is produced at four smelters, in electrolytic furnaces with pre-burnt anodes. The principal emission sources are the waste gases from the electrolytic furnaces and fugitive emissions via the hall roofs. The principal climate-relevant substances and pollutants emitted are CO, CO₂, SO₂, CF₄ and C₂F₆.

Production of primary aluminium continues to be the largest source of PFC emissions in Germany, in spite of the considerable reductions that have been achieved since 1990. Thanks to extensive modernisation measures in German aluminium smelters, and to decommissioning of production capacities, absolute emissions from this sector fell by 84 % between 1995 and 2008. As to the future development of PFC emissions, stagnation at a low level can be expected.

4.4.3.2 Methodological issues (2.C.3)

The production figures for the year 2009 were taken from the monitoring report by the aluminium industry for the year 2009 (GDA, 2009). The average anode consumption is 430 kg of petrol coke per tonne of aluminium. Table 96 shows the process-related emission factors.

The total quantity of waste gas incurred per tonne of aluminium during the production of primary aluminium was multiplied by an average concentration value formed from several individual figures, from various different plants, with appropriate weighting. The emission factors also make allowance for fugitive emission sources, such as emissions via hall roofs. The emission figures used for CO are the results of emission measurements within the context of investment projects.

The emission factors for SO₂ and CO₂ were calculated from the specific anode consumption. The anodes consist of petrol coke; this material has specific sulphur concentrations of about 1.2 %, from which an SO₂ emission factor of 10.4 kg/t Al can be calculated. The CO₂-emission factor is calculated on the basis of the specific carbon content of petrol coke, 857

kg per t. (cf. Chapter 18.6.2). By multiplying the average anode consumption by the mean carbon content and carrying out stoichiometric conversion to CO₂, one obtains a CO₂-emission factor of 1367 kg/t aluminium. Theoretically, the CO₂ emission factor must be reduced by the proportion resulting from a CO component of 180 kg/t Al, since CO can also form only via consumption of anodes. The CO₂ factor listed below does not take this into account.

The emission factors shown in Table 96 were compared with the emission data in Best Available Techniques Reference Documents (BREF)⁴³ and other sources (such as VDI Guideline 2286 sheet 1).

Table 96: Activity data and process-related emission factors for primary aluminium production in 2009

	Number of smelters	AD	Emission factors				
		Production [t]	CO ₂ [kg/t]	NO _x [kg/t]	SO ₂ [kg/t]	C total [kg/t]	CO [kg/t]
Primary aluminium	4	291,700	1367	N. e.	10.4	N. e.	180

Emission data is available for PFC emissions from primary aluminium smelters, thanks to a voluntary commitment on the part of the aluminium industry. Since 1997, the aluminium industry has reported annually on the development of PFC emissions from this sector. The measurement data are not published, but they are made available to the Federal Environment Agency.

The measurements conducted in all German smelters in the years 1996 and 2001 form the basis for calculation of CF₄ emissions. In this context, specific CF₄ emission factors per anode effect⁴⁴ were calculated, in keeping with the technology used. The number of anode effects is recorded and documented in the foundries. The total CF₄ emissions were calculated by multiplying the total anode effects for the year by the specific CF₄ emissions per anode effect determined in 2001. The total emission factor for CF₄ is obtained by adding the CF₄ emissions of the smelters and then dividing the sum by the total aluminium production of the smelters. C₂F₆ and CF₄ occur in a constant ratio of about 1:10. The above-described method was applied to the entire time series, and the emissions for the years 1990 to 1996 were filled in via recalculations.

4.4.3.3 Uncertainties and time-series consistency (2.C.3)

The figures for PFC, CO, CO₂ and SO₂ emissions are in keeping with the Tier 3b approach and thus are considered very accurate. The time series for CO, CO₂ and SO₂ are consistent.

On the other hand, in the framework of voluntary commitments no survey of the plant-specific number of anode effects in 1991, 1992, 1993 and 1995 was conducted, and no calculation was carried out for those years (cf. 4.4.3.6).

In addition, the years 1991 through 1994 were years of deep crisis for the German aluminium industry, due to sharp drops in the world-market prices for primary aluminium. For this reason, a number of plants were decommissioned. While all smelter types were affected, smelters that had recently been modernised, with point-feeder technology, were most

⁴³ cf. <http://www.bvt.umweltbundesamt.de/kurzue.htm>

⁴⁴ "...Organic fluorides occur only under certain conditions, and such conditions occur in the furnace repeatedly, at intervals of hours to several days. These conditions are referred to as the "anode effect". ... The gas at the anode changes in composition from CO₂ to CO and 5 to 20 % CF₄...." (ÖKO-RECHERCHE 1996)

strongly affected. Their capacity decreased by 43%, with regard to the relevant levels in 1990. This also explains the sudden increase and stagnation in the implied emission factor for CF₄ in these years. In absolute terms, the primary smelters emitted only 26 tonnes of CF₄ in 2007, while they emitted 45 tonnes in 2005. This drop was due to a decrease in production. With regard to 2006, production increased slightly, however, because partial shutdowns of furnaces in the Stade plant were more than offset by production increases at the Hamburg production site. In 2009, drastic reductions of production took place at the Rheinwerk Neuss site. As a result of the difficult economic situation at other German smelters, process instabilities repeatedly occurred that were caused by frequent start-up and shutdown processes. Presumably, those instabilities led to higher numbers of anode effects. The industry was unable to disclose its PFC emissions for this year on time, however. As a result, the relevant figures from 2008 had to be adopted for the following year.

4.4.3.4 Source-specific quality assurance / control and verification (2.C.3)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The industry conducts annual surveys of activity data and reports such data to (inter alia) the Federal Statistical Office and the Federal Office of Economics and Export Control. The relevant time series seems plausible and shows no inconsistencies. It is assumed that such data collection conforms to quality assurance criteria.

Specific PFC emissions during anode effects were determined via industry measurements carried out in 1996 and 2001 at all plants in Germany that produce primary aluminium. In each case, the amount of PFCs produced depends on the duration and frequency of the relevant anode effects. In recent years, the duration and frequency of anode effects have been considerably reduced via computer-aided process control. In 2008, the German emission factor for CF₄, resulting from anode effects, was 0.060 kg/t aluminium. That factor is thus of the same magnitude as the average international factor, as reported by the International Aluminium Institute (IAI), of 0.034 kg/t for point-feeder systems. Therefore, the emission factor has been verified.

4.4.3.5 Source-specific recalculations (2.C.3)

No recalculations are required.

4.4.3.6 Source-specific planned improvements (2.C.3)

Determination of uncertainties continues, with the involvement of the industry association. The correct PFC-emissions figures for 2009 will be provided in the next reporting round.

4.4.4 Metal production: SF₆ used in aluminium and magnesium foundries (2.C.4)

4.4.4.1 Source category description (2.C.4)

CRF 2.C.4					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1995 – contribution to total emissions	2009 – contribution to total emissions	Trend
SF ₆ used in Aluminium and Magnesium Foundries	- / -	SF ₆	C	C	C

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	NO	NO	D/CS	NO	NO	NO	NO	NO
EF uncertainties in %			-		0-50					
Distribution of uncertainties			-		T					
EF-determination method			NO		D/CS					

The source category *SF₆ used in aluminium and magnesium foundries* is not a key source.

Aluminium production:

Generally speaking, inert gases without additives are sufficient for rinsing secondary molten aluminium. A purification system of inert gases, with added SF₆ at a concentration of 1 or 2.5 %, has been used in the past, however, in a few – usually smaller – aluminium foundries and in laboratories. Such purification systems were last used in 1999 (no sales have taken place in Germany since 2000). From 1990 to 1999, SF₆ consumption remained relatively constant, at 0.5 t/a.

In isolated cases, pure SF₆ has been used again as a purification gas since 1999.

Magnesium production:

In magnesium casting, since the mid-1970s, SF₆ has been used as a protective gas over molten magnesium to prevent the magnesium's oxidation and ignition. The amount of SF₆ used per tonne of magnesium (specific SF₆ coefficient) has decreased sharply since 1995, since HFC-134a is increasingly being used as a substitute. SF₆ is used in both a) the sand-casting process, for production of prototypes, individual parts and small series, and b) the pressure-casting process, in which it serves as a protective gas.

4.4.4.2 Methodological issues (2.C.4)

Use of SF₆ as a purification and protective gas in magnesium production is an open use, i.e. all of the SF₆ used in the process is emitted into the atmosphere. The practice of assuming the equivalence between consumption (AD) and emissions conforms to the method in the IPCC Guidelines (IPCC, 1996a: page 2.34).

For aluminium foundries, the relevant emission factor has been established more reliably, via plant-specific measurements. As a result, the relevant emissions figures have been established more reliably as well.

Reports and archived survey records from 1996 have been used as a basis for the report years 1990 through 1994.

Emission factors

Until now, an emission factor of 100% has been assumed for aluminium foundries, because information relative to the extent to which SF₆ breaks down was lacking.

On the basis of confidential measurement records certified by the pertinent permit authority, the emission factor for the period 1999 through 2008 has been reduced to 3 %. Via structural conversions, the emission factor has been further reduced, to 1.5%, as of 2009.

For magnesium foundries, EF_{use} = 100% is assumed, due to a continuing lack of more precise decomposition-level data that would support a more precise estimate.

Activity data for aluminium production

SF₆-consumption data are obtained via surveys of gas sellers. At the same time, the survey for the 2000 report year revealed that there have been no sales of this gas mixture since 2000.

Data on the SF₆ used in pure form since 1999 have been obtained via direct surveys of users and have been compared with relevant data of gas sellers.

Since the 2007 report year, the data have been obtained by the *Federal Statistical Office* via surveys of gas sellers with regard to SF₆-sales figures.

Activity data for magnesium production

In 1996, a survey was carried out, under commission to the Federal Environment Agency, of all domestic magnesium foundries that use SF₆. That survey determined the amounts consumed in the years 1990 to 1995.

Until the 2007 report year, data on the amounts used were obtained directly from users. Since the 2006 report year, the data have been obtained via surveys of gas sellers with regard to SF₆-sales figures. In the 2006 report year, the two methods were compared.

Since the 2007 report year, data of the *Federal Statistical Office* have been used.

4.4.4.3 Uncertainties and time-series consistency (2.C.4)

As studies have shown, part of the SF₆ used in aluminium and magnesium production is broken down during such use. For this reason, the assumption that amounts used in magnesium production are emitted to a degree of 100 % probably overstates the emissions considerably. Without more precise measurements, for magnesium production, that would make it possible to determine an average degree of decomposition in the process, the uncertainties for the emission factors cannot be quantified.

For the aluminium industry, the emission factor has been applied to the highest measured emissions level, and an uncertainty of 50% has been assumed for lower levels, since measurements have shown that emissions are frequently considerably lower than the maximum levels.

4.4.4.4 Source-specific quality assurance / control and verification (2.C.4)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality assurance / control for amounts consumed in Mg foundries was carried out via a one-time comparison of findings from foundry surveys with producers' total SF₆ sales figures – and with data of gas sellers. For reported year 2007, additional findings resulting from a technical discussion held in December 2007 have been taken into account.

As to amounts consumed by Al foundries, for the 2002 report year, sales figures were compared for the first time with amounts used by industry, and this comparison revealed a discrepancy. That discrepancy has since been corrected. Sales figures and industrial usage quantities were compared for report year 2004 and showed good agreement.

4.4.4.5 Source-specific recalculations (2.C.4)

No recalculations are required.

4.4.4.6 Source-specific planned improvements (2.C.4)

No improvements are planned at present.

4.4.5 Metal production: Other (2.C.5)

CRF 2.C.5										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1995 – contribution to total emissions		2009 – contribution to total emissions		Trend			
	- / -									
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	D	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method			D							

For this source category, only emissions from use of HFC-134a in magnesium foundries are reported.

4.4.5.1 Source category description (2.C.5)

Since 2003, HFC-134a has increasingly been used, instead of SF₆, as a protective gas over molten baths.

4.4.5.2 Methodological issues (2.C.5)

data in magnesium production are identical with the comparable figures for use of SF₆ in magnesium production (2.C.4). For this reason, they are described in Chapter 4.4.4.2.

HFC-134a-emissions data are confidential, because of the small number of users involved. For this reason, the relevant emissions are reported in 2.G, in aggregation with other confidential data.

4.4.5.3 Uncertainties and time-series consistency (2.C.5)

The relevant uncertainties have been quantified.

4.4.5.4 Source-specific recalculations (2.C.5)

No recalculations are required.

4.4.5.5 Source-specific planned improvements (2.C.5)

No improvements are planned at present.

4.4.5.6 Source-specific quality assurance / control and verification (2.C.5)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.5 Other production (2.D.)

In the CSE, process-related emissions from production of particle board, and from pulp processing, are reported under 2.D.1 Pulp and paper.

Process-related emissions from production of alcoholic beverages, and from production of bread and other foods, are listed under 2.D.2 Food and drink.

4.5.1 Other production: Pulp and paper (2.D.1)

4.5.1.1 Source category description (2.D.1)

CRF 2.D.1					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1995 – contribution to total emissions	2009 – contribution to total emissions	Trend	
- / -					

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	NO	NO	NO	NO	CS	CS	D	D
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category *Other production – Pulp and paper* is not a key source.

All emissions of climate-relevant gases from the pulp and paper industry in Germany result from combustion of fuels; for this reason, they are reported in Chapter 3.2 as energy-related emissions. The pulp and paper industry does not produce any process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (2000).

Two of the six pulping plants in Germany carry out sulphate-process pulp production via caustification. For these plants, fuel-related CO₂ emissions in lime ovens are already taken into account, as energy-related emissions, via the pertinent fuel statistics. The remaining four plants use the sulphite process.

No attempt was made to take account of country-specific CO emission factors in energy-related emissions from pulp production, since that would have required conversion of product-based emission factors into fuel-based emission factors. Such conversion is an extremely involved process. Compared to the relevant CO emissions from paper mills, the CO emissions from the six pulping plants are of insignificant quantities.

The sulphate and sulphite pulp-production processes can both be a source of SO₂ emissions. In sulphate pulp production, NO_x, CO and NMVOC emissions are also released from recovery boilers, lime ovens, bark boilers and auxiliary boilers.

A detailed description of the relevant processes – in the present example, fibre production (including wood-pulp production) and paper and carton production – and supplementary information about auxiliary boilers are provided in Annex 3, Chapter 19.2.4.1.

4.5.1.2 Methodological issues (2.D.1)

The pulp, paper and printing industry produces no process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (IPCC, 2000). For indirect greenhouse gases, the IPCC-Guidelines emission factors listed in Table 97 were used until the reported year 2004.

Table 97: IPCC default emission factors for SO₂, NO_x CO and NMVOC from pulp production

	NO _x	CO	NMVOC	SO ₂
	[kg / t ADt*]			
Sulphate pulp	1.5	5.6	3.7	7
Sulphite pulp				30

* ADt = Air-dried tonne

As of reported year 2005, plant operators have provided updated emission factors.

Table 98: Real emission factors, for German plants, from pulp production. (German contribution to revision of the BAT reference (BREF) document for the pulp and paper industry, 2007)

	NO _x	CO	NMVOC	SO ₂
	[kg / t ADt*]			
Sulphate pulp	1.75	0.16	3.7	0.05
Sulphite pulp	2.8			2

In 2008 the following quantities were produced, in a total of 138 plants:

Table 99: Pulp and paper production, produced quantities

Product	Quantities produced in 2009	
Production of paper, cardboard and carton (PCC):	20,95Millions of tonnes	
Raw-material production:		
Paper pulp	1,481,230	t
of this, sulphite pulp	692,450	t
of this, sulphate pulp	3,609,601	t
Wood pulp	1,059,889	t
Recycled paper	12,353,000	t
Quantity of recycled paper used for this purpose	(15,399,121	t)

Source: Verband Deutscher Papierfabriken, Leistungsbericht 2010

These figures can be traced back to the base year, 1990.

4.5.1.3 Uncertainties and time-series consistency (2.D.1)

Until reported year 2004, the IPCC default values (IPCC, 1996b) were used for emissions calculation. As of reported year 2005, updated, Germany-specific emission factors were entered into the CSE emissions database, following consultation with German plant operators. Such updating was required because German sulphate pulp plants had undertaken considerable modernisation measures, in the previous five years, that had led to sharp emissions reductions. The updating was completed as of 2005. In sulphite pulp plants, continual improvements led to considerable SO₂-emissions reductions with respect to corresponding emissions levels in 1990.

4.5.1.4 Source-specific quality assurance / control and verification (2.D.1)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.5.1.5 Source-specific recalculations (2.D.1)

No recalculations are required.

4.5.1.6 Source-specific planned improvements (2.D.1)

Since plant operators have confirmed the emission factors from the international guidelines, no further inventory improvements for this source category are planned at present.

The CO₂ emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do not have to be reported. In future, CO₂ of biogenic origin may also be reported, in the interest of enhancing transparency.

4.5.2 Other production: Food and drink (2.D.2)

4.5.2.1 Source category description (2.D.2)

CRF 2.D.2					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
- / -					

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	IE	NO	NO	NO	NO	NO	NO	NO	CS / IPCC	NO
EF uncertainties in %									20 - 100	
Distribution of uncertainties									N	
EF-determination method									CS	

The source category *Other production – Food and drink* is not a key source.

The food and beverage industry's emissions of direct climate gases in Germany result from fuel combustion; for this reason, they are reported under CRF 1.A.2. The food and beverage industry's important process-related emissions include non-methane volatile organic compounds (NMVOC) (IPCC 1996c: p. 2.41). Carbon dioxide emissions from food inputs that occur during certain production processes are not reported in CRF 2.D.2., since they result from use of biological carbon and do not contribute to net CO₂ emissions. Solvent emissions related to production of margarine and vegetable oils are reported in source category 3.D. Animal fats are thus included in the source category "Margarine and solid and hardened fats". CO₂ used in sugar production, which is obtained from burning of limestone, is bound during the production process. For this reason, this process is not emissions-relevant (cf. UFOPLAN research project FKZ 205 41 217/02).

Emissions of the food and drink industry are reported, in summary form, in the inventory in "Table2(l)s2" of the sectoral report for industrial processes. In the table "Background data of the sectoral report for industrial processes" ("Hintergrunddaten des sektoralen Reports für Industrielle Prozesse"), "Table2(l).A-G", the IEF is listed as NE, since the pertinent CO₂ emissions are reported under CRF 1.A.2.

With revenue of EUR 149 billion in 2009, the food industry is one of Germany's most important economic sectors. In that same year, 535,000 people were employed in food-industry companies (BVE 2010, p. 10). The German food industry includes an especially large number of small and medium-sized enterprises (SMEs); nearly 80 percent of its companies have fewer than 100 employees, and only 3 percent have more than 500 employees (BpB 2002, p.51).

Pursuant to the IPCC, emissions reporting for the food and drink source category covers the following products:

Alcoholic beverages

- Wine
- Beer
- Spirits

Bread and other foods

- Meat, fish and poultry
- Sugar
- Margarine and solid and hardened fats
- Cake, cookies and breakfast cereals
- Bread
- Animal feedstuffs
- Coffee roasting

Default emission factors for NMVOC emissions relative to these products are listed (IPCC, 1996c: p. 2.41f):

4.5.2.2 Methodological issues (2.D.2)

For emissions calculations, national emission factors were used where available. Otherwise, the emission factors recommended by IPCC and CORINAIR were used.

The Central System of Emissions (CSE) lists activity data (produced amounts) and emission factors for NMVOC emissions for the relevant sectors. The activity data for the various products / product groups, with the exception of that for feedstuffs, were obtained from the *FEDERAL STATISTICAL OFFICE* (Fachserie 4, Reihe 3.1 and Fachserie 3, Reihe 3.2.2). The activity data for feedstuffs were obtained from the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) (Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten). Because of its greater precision, the distilled-spirit tax (Branntweinsteuerstatistik) of the *Federal Statistical Office* was used to determine the activity data for spirits production.

Table 100 shows the activity data determined, emission factors used and the relevant NMVOC emissions calculated for the year 2009.

Table 100: NMVOC emissions from the food industry (2.D.2)

Product	Activity data	Emission factors	Emissions [t]
Bread			
- Industrial bakeries	3, 720,588 t	0.3 kg/t	1,116.2
- Craft bakeries	914,696 t	3.0 kg/t	2,744.1
Cake, cookies and breakfast cereals	1,553,533 t	0.1 kg/t	155.4
Sugar	4,140,519 t	0.9 kg/t	3,726.5
Meat, poultry, fish	1,496,775 t	0.03 kg/t	44.9
- Meat/fish, smoked	2,271,574 t	0.0023 kg/t	5.2
Animal fats	322,390 t	1 kg/t	322.4
Coffee roasting	537,495 t	0.069 kg/t	37.0
Feedstuffs	18,674,536 t	0.1 kg/t	1,841.5
Beer	90,136,860 hl	0.002 kg/hl	180.31
Wine			
- Red wine	3,764,078 hl	0.08 kg/hl	301.1
- White wine	5,062,188 hl	0.035 kg/hl	177.2
- Other wines	1,032,190 hl	0.058 kg/hl	59.9
Spirits	1,175,299 hl	2.93 kg/hl	3,443.6

* With reduction measures taken into account

A total of 14.2 Gg of NMVOC emissions result for source category 2.D.2.

4.5.2.3 Uncertainties and time-series consistency (2.D.2)

The uncertainties in the activity data are estimated to amount to 5-20 %. A research project was carried out (FKZ 206 42 101/01), in the UFOPLAN framework, with the aim of improving the database and facilitating maximally realistic estimation of emissions from the food industry. That research project was able to determine national emission factors for a number of source areas (sugar production, spirits production, coffee roasting, smoking of meat and fish), to obtain more-detailed information with regard to the nature and scope of emissions-reduction measures in the various sectors and to improve the database for determination of activity data. Where no national emission factors were available, emission factors from the IPCC Workbook (1996a, 2.41f) and the Emission Inventory Guidebook (AEIGB, 2008) were used. For determination of emissions from production of other wines (fruit wines), the average of the emission factors for red-wine and white-wine production was used.

4.5.2.4 Source-specific quality assurance / control and verification (2.D.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Other countries' reports contain very little information about 2.D.2, and thus no comparisons are possible at present.

4.5.2.5 Source-specific recalculations (2.D.2)

Source-specific recalculations were carried out in the following source categories: spirits; cakes, cookies, breakfast cereals; meat, fish and poultry; animal fats and feedstuffs, since it proved possible to improve some of the pertinent activity-rate data.

4.5.2.6 Source-specific planned improvements (2.D.2)

No improvements are planned at present.

4.6 Production of halocarbons and SF₆ (2.E)

CRF 2.E					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1995 – contribution to total emissions	2009 – contribution to total emissions	Trend
	l / t	HFC	C	C	C

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NO	NO	PS	NO	PS	NO	NO	NO	NO	NO
EF uncertainties in %			-		-					
Distribution of uncertainties			-		-					
EF-determination method			-		-					

The source category *Production of halocarbons and SF₆* is a key source of HFC emissions in terms of emissions level and trend. It is subdivided into 2.E.1 By-product emissions and 2.E.2 Fugitive emissions.

4.6.1 By-product emissions (2.E.1)

4.6.1.1 Source category description (2.E.1)

For process-related reasons, production of HCFC-22 produces up to 3 % HFC-23 as a by-product. For technical reasons, even when the HFC-23 is subjected to further processing (for example, to produce refrigerants) or is collected and then broken down into other substances, some HFC-23 is always released into the atmosphere.

Germany still has two production plants for HCFC-22. Those two plants, which are operated by a single company, are located in Frankfurt and Bad Wimpfen. In 1995, a CFC-cracking plant went into operation in Frankfurt that cracks, at high temperature, excess HFC-23 produced during production of HCFC-22 and that recovers hydrofluoric acid; i.e. no significant emissions are produced. HFC-23 produced at the second German production facility is captured in large amounts at the production system itself; the substance is then sold as a refrigerant or – following further distillative purification – as an etching gas for the semiconductor industry. Since 1999, the excess amount that cannot be sold has been delivered to the cracking facility in Frankfurt. That measure has substantially reduced emissions. The emissions level of 0.5 % of CFC production, the level estimated by the operator for 2002, has been further reduced, sharply, via improved collection equipment.

4.6.1.2 Methodological issues (2.E.1)

In keeping with manufacturer information from 1996, HFC-23 emissions are assumed to have remained constant in the years 1990 to 1994.

Since 1995, the producer has calculated emissions, via a mass-balance procedure, on the basis of HCFC-22 production, HCFC-23 concentrations in exhaust gas (as measured annually), sales of HFC-23 and quantities of HFC-23 delivered to the cracking plant. For report year 1995, emissions-reduction measures (the cracking plant) for the first production plant were assumed to have been in place since mid-year.

Emission factors

Since produced quantities of HCFC are not reported, no emission factor can be determined and compared with the IPCC standard emission factor.

Activity data

The producer reports emissions of HFC-23.

Since there are fewer than three producers in Germany, the pertinent emissions data are confidential. They are reported in aggregation with other confidential data in 2.G.

4.6.1.3 Uncertainties and time-series consistency (2.E.1)

The production figures used as a basis for emissions calculation may be considered highly accurate, since they come directly from the producer's internal records.

4.6.1.4 Source-specific quality assurance / control and verification (2.E.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.6.1.5 Source-specific recalculations (2.E.1)

No recalculations are required.

4.6.1.6 Source-specific planned improvements (2.E.1)

No improvements are planned at present.

4.6.2 *Production-related emissions (2.E.2)*

4.6.2.1 Source category description (2.E.2)

In Germany, one company produces these gases; its HFC and SF₆ production takes place at two locations. Emissions trends are tied to trends in amounts produced. While SF₆ and HFC-134a are produced in Germany, until 2008 no complete synthesis of HFC-227ea was carried out in Germany. Part of the HFC-227ea produced in Tarragona, Spain, undergoes subsequent distillation, in Germany, to pharmaceutical purity (use in dosing aerosols). That process produces emissions as a result of minor gas losses.

HFC-134a has been produced since 1994, while HFC-227ea has been produced since 1996.

4.6.2.2 Methodological issues (2.E.2)

Emission factors

It is possible to calculate an emission factor from the emissions and production quantities reported by the producer. The resulting factor is not published, however, because the underlying data are confidential.

Activity data

Because the HFC producer in Germany is the country's sole producer, that company's data are confidential. Emissions and production quantities are reported to the Federal Environment Agency, but only in a form aggregated with emissions from CRF source category 2.E.1.

4.6.2.3 Uncertainties and time-series consistency (2.E.2)

The production figures used as a basis for emissions calculation may be considered highly accurate, since they come directly from the producer's internal records.

4.6.2.4 Source-specific quality assurance / control and verification (2.E.2)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.6.2.5 Source-specific recalculations (2.E.2)

No recalculations are required.

4.6.2.6 Source-specific planned improvements (2.E.2)

No improvements are planned at present.

4.6.3 Other (2.E.3)

No other sources of greenhouse-gas emissions are known.

4.7 Consumption of halocarbons and SF₆ (2.F)

CRF 2.F										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1995 – contribution to total emissions	2009 – contribution to total emissions	Trend					
Consumption of Halocarbons and SF ₆	l / t	SF ₆	0.53 %	0.31 %	-55.2 %					
Consumption of Halocarbons and SF ₆	l / t	HFC	0.18 %	1.19 %	+397.3 %					
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)			s. Text	s. Text	s. Text					
EF uncertainties in %			-	-	-					
Distribution of uncertainties			-	-	-					
EF-determination method			s. Text	s. Text	s. Text					

The source category *Consumption of halocarbons and SF₆* is a key source of SF₆ and HFC emissions in terms of emissions level and trend.

Source category 2.F includes Refrigeration and air conditioning systems (2.F.1), Foam production (2.F.2), Fire extinguishing agents (2.F.3), Aerosols (2.F.4), Solvents (2.F.5), Semiconductor production (2.F.6), Electrical operating equipment (2.F.7) and Other applications (2.F.8). In the interest of more precise data collection, these sub- source categories are broken down further, as described in the following sub-chapters.

Use of relevant substances as refrigerants in stationary and mobile refrigeration applications, which accounts for over three-fourths of relevant emissions, is the largest source of HFC emissions in source category 2.F from use of fluorinated greenhouse gases. The remaining emissions are distributed among the sources "foams" and "aerosols" and, in small amounts, "fire extinguishers", "solvents", "semiconductor manufacturing" and "photovoltaic-module production".

Some two-thirds of PFC emissions come from the semiconductor industry (which includes circuit boards; due to its insignificance in this context, that category is not reported

separately), and one-third come from air-conditioning and refrigeration systems. Small quantities are emitted from shoes and from production of photovoltaic modules (PV modules).

About half of the SF₆ emissions come from sound-proof glazing, with emissions in that area occurring primarily in disposal of sound-proof glazing. About one-fourth of the emissions originate from electrical equipments. As to the remaining emissions, production of PV modules is the predominant source, followed by production of optical glass fibres. Small amounts originate in the semiconductor industry, from automobile tyres and from trace gases. No information can be provided regarding quantities for the emissions sources "shoes", "AWACS" and "welding", since the relevant data are confidential.

Table 101: Overview of methods and emission factors used for the current report year, in source category 2.F - Consumption of halocarbons and SF₆.

		Method	Gas			Emission factor (dimensionless)				
			HFC	PFC	SF ₆	Production	Application	Disposal		
1. Air-conditioning and refrigeration systems	2.F.1									
Household refrigeration	2.F.1a	Tier 2a	HFC			NO	0.003 (D)	0.3 (D)		
Commercial refrigeration	2.F.1b			PFC		0.002 (CS)	0.015 - 0.15 (D)	0.3-0.5 (CS)		
Transport Refrigeration (vehicles and containers)	2.F.1c			PFC		0.005 (D)	0.10 - 0.30 (D)	0.3 (D)		
Industrial refrigeration	2.F.1d			PFC		0.0015 (CS)	0.07 (D)	0.3 (CS)		
Stationary air conditioning systems	2.F.1e					0.01 (D)	0.06 (D)	0.3 (CS)		
Room air conditioners						0.025 (CS)	0.025 (D)	0.3 (D)		
Mobile air conditioning systems	2.F.1f									
- Trucks						2 g/system (CS)	0.10 - 0.15 (D)	0.3 (D)		
- Automobiles						2 g/system (CS)	0.1 (D)			
- Busses						5 g/system (CS)	0.15 (D)			
- Ships						0.01 (CS)	0.1 – 0.3 (CS)			
- Railway vehicles						0.002 (CS)	0.06 (CS)			
- Agricultural machines						5 g/system (CS)	0.15 - 0.25 (CS)			
2. Foam production	2.F.2									
Hard foam with 134a	2.F.2a	Tier 2a	HFC			0.1 (D)	0.005 (D)	NO		
Hard foam with 365mfc/245fa/227ea						0.15 (CS)	0.01 (CS)			
Integral foam						1 (CS)	NO			
PUR foam (134a)						0.5 g/can (CS)	1 (CS)			
PUR foam (152a)						0.5 g/can (CS)	1 (CS)			
XPS foam (134a)						C	0.0066 (CS)			
XPS foam (152a)						1 (CS)	NO			
3. Fire extinguishers	2.F.3	CS	HFC			0.001 (CS)	0.01 – 0.08 (CS) 0.04 (D)	NO		
4. Aerosols	2.F.4									
Metered dose inhalers	2.F.4a	CS	HFC			0.01 (CS)	1 (CS)	NO		
Other aerosols / novelties	2.F.4b/c	Tier 2				0.015 (CS)	1 (D)			
5. Solvents	2.F.5	Tier 2				NO	1 (D)			
6. Semiconductor production	2.F.6	Tier 2a		PFC	SF ₆	C (CS)	NO			
7. Electrical equipments	2.F.7									
Switchgear and controlgear	2.F.7a	Tier 3a			SF ₆	0.02 (CS)	0.001 – 0.01 (CS)	0.015 (CS)		
Other	2.F.7b	CS				0.15 – 1 (CS)	0.006 – 0.003 (CS)	NO		
8. Other	2.F.8									
Sound-proof glazing	2.F.8a	Equ. 3.24 ff			SF ₆	0.33 (D)	0.01 (D)	1 (D)		
Car tyres	2.F.8b	Equ. 3.23				NO	NO	1 (D)		
Sports shoes	2.F.8c	Equ. 3.23		PFC		NO	NO	1 (D)		
Trace gas	2.F.8d	Equ. 3.22				NO	1 (D)	NO		
AWACS maintenance	2.F.8e	CS				NO	C	NO		
Welding	2.F.8f	CS				NO	1 (CS)	NO		
Optical glass fibre	2.F.8g	CS				0.7 (CS)	NO	NO		
Photovoltaics	2.F.8h	CS				0.058 (CS)	NO	NO		

Equ. = Equation from the IPCC GPG (2000)

Halocarbons and SF₆ are used in a number of different applications. Whereas in some, so-called "open" applications, consumed quantities are emitted completely, in the same year in question, in other applications large quantities are stored (stocks). The substances then are

emitted, either partially or completely, from such "stocks" throughout the entire usage phase and in relevant waste management. It is thus neither possible nor useful to provide a mean emission factor. Most of the EF used are country-specific (CS), although some are also IPCC default (D).

The "current emissions (A)", as listed in Table 2(II)s2 of the inventory tables, consist of the quantities of HFCs, PFCs and SF₆ that, during a report year, slowly escape from "stocks" and are emitted in production and waste management. On the other hand, the "stocks" – actually, the average quantities present in the report year in question (average annual stocks) – correspond to the potential emissions (P) listed in Table 2(II)s2. The "stocks" do not include quantities from storage only. Those amounts vary widely, and thus neither is it possible to determine these quantities nor is it useful to work with an average value. For reasons of confidentiality, potential emissions for the sub- source categories "solvents" and "semiconductor manufacture" cannot be given. For open applications (aerosols / metered dose inhalers), annual emissions are equated with the quantities sold within the relevant 12-month period (100 % emissions in the relevant year of sales). As a result, this area has no "stocks" that increase annually. The potential emissions thus correspond approximately to the current emissions in the report year in question. In individual cases involving "open" applications, a situation can arise, as a result of the calculation method chosen and the difference in reference period, in which $A > P$ and, thus, the relationship $P/A < 1$ (ÖKO-RECHERCHE, 2004).

In general, the emissions data collected for the various product groups comprise emissions from production, use and waste disposal. Except where indicated otherwise in connection with the pertinent methods, these emissions are calculated as follows:

1. Production emissions are determined via new domestic consumption, as an activity data:

Equation 1:

$$EM_{\text{production}} = EF_{\text{production}} * \text{domestic new consumption}$$

2. Application emissions are based on the average annual stock of relevant pollutants (the activity data), and they are calculated via the following formula:

Equation 2:

$$EM_{\text{application}} = EF_{\text{application}} * \text{Average stocks}$$

These average stocks are obtained as half of the sum of the final stocks of the previous year (n-1) and of the current year (n); summation is carried out from the first year of application on. The result consists of the accumulated average pollutant stocks for year n.

The final stocks for the current year are calculated by summing annual new additions, from the first report year to the current one. The new additions for a given year consist of the new domestic consumption for that year, minus production emissions and losses from removals. The calculation thus requires consideration of foreign trade.

3. Disposal emissions refer to new additions for the year that is x years (depends on product lifetime) prior to the current report year n:

Equation 3:

$$EM_{\text{disposal}} = EF_{\text{disposal}} * \text{New additions (n-x)}$$

In this chapter, the sections *Uncertainties and time-series consistency*, *Source-specific quality assurance / control and verification*, *Source-specific recalculations* and *Planned improvements* vary in their reference – some refer to the entire relevant source category, some to the sub - source category in question and some to only a part of a sub - source category. In each case, the reference involved is apparent from the CRF number in the section heading.

4.7.1 Refrigeration and air conditioning systems (2.F.1)

4.7.1.1 Source category description (2.F.1)

This category is divided into the sub-categories of household refrigeration, commercial refrigeration, transport refrigeration, industrial refrigeration, stationary air-conditioning systems and room air-conditioners, and mobile air-conditioning systems (cf. Table 101).

In Germany, the leading pure-HFC refrigerants, far and away, are HFC-134a and the mixtures 404A and 507A.

For calculation of HFC emissions from the sub-categories of refrigeration and stationary air conditioning systems, individual data are collected, or refrigerant models are used. Any refrigerant models used are described in connection with the relevant method.

The emission factors used are the result of surveys of experts. Disposal emissions in this source category first occurred in 2002, in sub- source category 2.F.1.f (automobile air conditioners).

4.7.1.2 Methodological issues (2.F.1)

4.7.1.2.1 Household refrigeration (2.F.1.a)

In 1994, domestic producers of household refrigerators and freezers made a changeover from CFC-12 to HFC-134a. A short time later, they then switched to isobutane. A few devices containing HFC-134a, representing a small share of all relevant appliances, are imported.

Equation 2 is used to calculate annual HFC emissions on the basis of average stocks. To that end, annual HFC additions since 1994 are determined and aggregated.

Production losses and new consumption for domestic purposes do not have to be determined, since filling takes place only abroad.

Emission factors

Current HFC emissions from household refrigerators and freezers are estimated at 0.3 %, which is within the value range given by IPCC–GPG (2000) in Table 3.22.

The emission factor for disposal, at a value of 30 %, is in keeping with the value given by IPCC–GPG (2000) in Table 3.22.

Activity data

The annual additions figure of 1 % of new appliances is an estimate of leading refrigerator manufacturers.

The appliances in question are considered to have an average lifetime of 15 years. That value lies within the upper section of the value range given by IPCC–GPG (2000) in Table 3.22.

4.7.1.2.2 *Commercial refrigeration (2.F.1.b)*

Commercial refrigeration is the largest and most diverse area of HFC application. It is roughly divided into general food retail and other commercial refrigeration. The great diversity of refrigeration systems involved, with regard to model, size, type of refrigerant and emissions-tightness, results from the fact that most relevant systems are customised systems. This is true to a lesser extent in the retail food sector. In light of the extremely large number of companies specialising in refrigeration, detailed statistical surveys of refrigerant stocks are not practicable. Therefore, a different calculation method is used.

Use of HFCs as refrigerants grew only gradually. For example, HFC-134a was not used on any significant scale until mid-1993. The refrigerant mixture R404A was also not used until 1993. The refrigerant mixture R508B has been in use since 1996, and R407C has been in use only since 1997.

Today, the mixture R404A is the most important HFC refrigerant for stationary refrigeration systems, ranking ahead of even HFC-134a in this category. The mixtures R407C and R508B are also of some significance.

In its basic characteristics, the following refrigeration model also holds for industrial refrigeration systems. Pertinent differences between the two areas are described in the present section.

- Foreign trade with locally installed refrigeration systems plays a negligible role, and thus annual HFC consumption for new systems is the same as new HFC additions in new systems. First, the refrigerant stocks are estimated for the target state in which all existing refrigeration systems contain only HFCs (no HCFCs).
- To this end, the entire *commercial refrigeration* sub-category is divided into numerous different device categories, in accordance with the criteria of application area / type of shop (for example, small supermarket) and system type (for example, central system). Due to the large differences involved, a distinction is also made between target stocks for the category "food sales" and those for the category "other commercial refrigeration".
- The entire sub-category of *industrial refrigeration* is divided into numerous applications. Divisions are defined by industrial sector and pertinent refrigeration area (normal refrigeration, low-temperature refrigeration and freezing). In the area of the food and drink industry, divisions based on individual product groups are also defined.
- The type of refrigerant and numbers of relevant systems involved are determined for each system/device category and application. In addition, the installed refrigeration output, in kW per system, and the specific refrigerant quantity, in "kg per installed kW", are established and assumed to be constant. The product "Number of systems * installed refrigeration output * specific refrigerant quantity" is the total amount of refrigerant in question.
- In the area of *commercial refrigeration*, for general food sales refrigerant quantities are first determined separately for normal and low-temperature refrigeration and then summed. The resulting sum is then divided among 404A and 134a in accordance with a ratio of 80 to 20. Then, the data are combined into the categories of central systems (high emissions) and reciprocating compressors (low emissions).
- In the category of *other commercial refrigeration*, the data are combined into the categories of plug-in ready single appliances and installed stationary systems.

- The target stocks, in connection with the average service lifetimes (10 years) for industrial and commercial refrigeration systems, can then be used to calculate how much refrigerant must be filled annually into new systems (new additions) in order to maintain stocks in the face of removals of old systems (1/10 of stocks). The "average yearly stocks" can also be determined for both areas.
- Since HFCs did not completely supplant chlorine-containing refrigerants in new systems as of a certain date, to obtain annual consumption of HFC refrigerants, one must weight the calculated additions for new systems with the relevant HFC share.
- In the area of *commercial refrigeration*, replacement of CFCs in old systems is considered separately, without any distinction between food sales and other commercial refrigeration.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2. Production normally takes place at the relevant sites.
- In the area of *commercial and industrial refrigeration*, disposal emissions occurred for the first time in 2003. They are calculated by means of Equation 3.

Emission factors

Except for EF_{disposal} , the emission factors used are the result of surveys of experts and of evaluations of the literature.

As a rule, filling of refrigeration systems produces only small quantities of emissions. For "initial emission", IPCC-GPG gives a figure of 0.5 to 3 percent of the initial filling quantity. The country-specific $EF_{\text{production}}$, at 0.2 %, is much lower than that figure.

Ongoing (H)FC emissions from stationary refrigeration systems in the *commercial refrigeration* area vary widely in keeping with the type of system concerned. Refrigerant losses range from 1.5 % for individual appliances (except for those in food sales) to 15 % for old devices. These values are in the lower range of pertinent values given by IPCC-GPG (2000).

The emission factor for disposal, at 30 % and 50 % for converted CFC-12 systems, is higher than the magnitude given by IPCC-GPG (2000), 10 to 30 percent for commercial refrigeration systems.

Activity data

The pertinent number of equipment operators, and the types of refrigeration equipment (i.e. as sets) commonly involved, have been generally assessed by experts who have carried out direct surveys of equipment suppliers and users. The specification "average refrigeration fill, in kg per kW of refrigeration output" has been determined semi-empirically by experts, with the help of technical literature.

4.7.1.2.3 *Transport refrigeration (refrigerated vehicles and containers) (2.F.1.c)*

HFCs have been used since 1993 as refrigerants in *refrigerated vehicles*. Today, the refrigerants most commonly used in refrigerated vehicles are HFC-134a and the refrigerant mixtures R404A and R410A. The sizes and refrigerant fill quantities of refrigeration systems vary in keeping with the load volumes of the refrigerated vehicles in question.

Refrigerated containers are used primarily for transports of perishable goods by ocean-going ships. Since their emissions take place primarily in international waters, their refrigerant

emissions are divided, in each case, in keeping with the relevant country's share of world trade. Germany is assigned 10% of global emissions from refrigerated containers. Since 1993, the most commonly used refrigerant has been HFC-134a. R410A has also been used since 1995, and R404A has also been used since 1997.

The following refrigeration model is applied to *refrigerated vehicles*:

- The entire sub-category of *transport refrigeration* is divided into four size classes of refrigerated vehicles: 2-5 t, 5-9 t, 9-22 t and > 22 t of permissible gross vehicle weight.
- Fixed refrigerant types, and specific refrigerant fill amounts, are assigned to the various size classes. Each refrigerant is also assigned a fixed share of each size class. In some cases, the refrigerant breakdown used may have to be modified. Since report year 2006, the refrigerant R404A has been used in half of the small systems of up to 5 t gross vehicle weight. Until 2005, only HFC-134a was used. Since 1993, relevant filling has consisted of 50 % HFC-134a and 50% R404A in the size class 5-9 t gross vehicle weight, while HFC-134a, R404A and R410A have been used in the size classes 9-22 t and > 22 t.
- The number of newly licensed refrigerated vehicles, and the number of refrigerated vehicles filled within the country (broken down by refrigerants), are determined for each year. The annual new additions of refrigerants result from the numbers of newly licensed refrigerated vehicles and the above assumptions.
- When one knows the final stocks from the previous year, one can calculate the average yearly stocks and the year-end stocks.
- In conformance with the Ordinance on CFC-halon prohibition (FCKW-Halon-Verbotsordnung), HFCs were substituted for CFC-12 in a certain number of old systems. These amounts have to be included in the annual new additions.
- Production emissions are calculated with Equation 1, since they must be seen in connection with new consumption. No use is made of the possibility of calculating emissions on the basis of numbers of newly filled vehicle refrigeration systems, and of the filling loss per system. Emissions from stocks are calculated with Equation 2.
- A service lifetime of 10 years is assumed. Disposal emissions occurred in connection with refrigerated vehicles for the first time in 2003. They are calculated by means of Equation 3.

The "bottom-up" approach described in IPCC-GPG (2000) refers only to refrigerated vehicles on roads.

For *refrigerated containers*, the following refrigerant model is used:

- The number of refrigerated containers produced worldwide is determined for each year.
- The worldwide HFC additions for refrigerated containers are determined on the basis of annual unit figures from global production, in combination with the relevant fill quantities and fill percentages for the various relevant refrigerants.
- Germany's HFC additions are determined from worldwide additions, in keeping with Germany's share of global trade, which amounts to 10 %.
- When one knows the final stocks from the previous year, one can calculate the average yearly stocks and the year-end stocks.
- Emissions from stocks are calculated with Equation 2.

- Since refrigerated containers are produced only outside of Germany, no emissions from filling occur in Germany.
- Refrigerated containers have an average lifetime of 14 years, and disposal emissions from such containers occurred for the first time in 2007. They are calculated by means of Equation 3.

Emission factors

The emission factors on which the emissions data are based are listed in Table 101. The emission factors used lie within the ranges recommended in the *IPCC Guidelines 2006*; they are thus *default values*.

Ongoing HFC emissions from new refrigeration units of refrigerated vehicles in the range 5-22 t gross vehicle weight are estimated to amount to 15 %. For units in vehicles up to 5 t gross vehicle weight, the emission factor is 30 %.

For old units, the factor is estimated to average 25 %, for all unit size classes. "Old systems" are understood to be converted CFC-12 systems. The emissions are thus at the lower limit of the standard value given in IPCC-GPG (2000). The lifetime of old systems, at 7 years, is within the proposed values, while the lifetime of new systems, at 10 years, is somewhat higher than the upper limit given in IPCC-GPG (2000).

Filling losses are small by comparison to ongoing emissions from stocks. Filling losses of refrigerant, in filling of refrigerated vehicles, are placed at 5 grams per system, regardless of system size. That is a standard value for hose losses during on-site filling. A mathematical comparison of filling emissions to new consumption produces a ratio of 0.2 % for HFC-134a and a ratio of 0.05 % for R410A. Those values lie far below the range given by the IPCC-GPG, 0.2 to 1 percent.

Ongoing HFC emissions from refrigeration systems of refrigerated containers are estimated at 10 %. No emissions from filling of refrigerated containers occur in Germany.

The emission factor for disposal of refrigerated transport systems, at 30 %, lies at the upper boundary of the range given in IPCC-GPG (2000), 20 to 30 percent.

Activity data

Until 2008, the registration figures for refrigerated vehicles, broken down by weight classes, were taken from statistical reports of the Federal Motor Transport Authority. As of 2009, experts from the leading German producer of refrigerated vehicles report the numbers of new refrigerated vehicles, since the Federal Motor Transport Authority does not carry out any surveys of refrigerated vehicles. Fill quantities in refrigeration systems, information on refrigerants used, and details on CFC-12 replacement were provided by experts of the leading providers of vehicle refrigeration units.

New additions of refrigerants in the area of refrigerated containers are determined externally, using a refrigerant model based on global new additions of refrigerated containers. A 10 % share is allocated to Germany.

4.7.1.2.4 Industrial refrigeration (2.F.1.d)

The industrial refrigeration included in this sector refers to refrigeration for production of products – mostly food and drink – that are refrigerated or frozen.

Refrigeration systems in this area, as in the area of *commercial refrigeration*, are usually not taken directly from series production. They tend to be customised systems, and thus the refrigeration model for this area is similar to that for *commercial refrigeration*. On the other hand, use of fluorine-based refrigerants has not yet become standard practice in industrial applications. In addition, natural refrigerants are used much more frequently, especially in the food industry.

Along with HFCs – which are also used in *commercial refrigeration* – HFC-227ea also plays a role (at higher temperatures).

The refrigeration model used is similar to that used for *commercial refrigeration*. It is thus described in the section for commercial refrigeration.

Emission factors

The emission factors on which the emissions data are based are listed in Table 101.

The emission factors used are the result of surveys of experts and literature evaluations.

As a rule, filling of industrial refrigeration systems produces only small quantities of emissions. For "initial emission", IPCC-GPG (2000) gives a figure of 0.5 to 3 percent of the initial filling quantity. The country-specific $EF_{\text{production}}$, at 0.15 %, is lower than that figure.

Current HFC emissions from industrial refrigeration systems are estimated at 7 %, which is in the lower segment of the value range given by IPCC-GPG (2000) in Table 3.22.

The emission factor for disposal of industrial refrigeration systems, at 30 %, is higher than the range given in IPCC-GPG (2000), 10 to 20 percent.

4.7.1.2.5 Stationary air conditioning systems (2.F.1.e)

The category of *stationary air conditioning systems* includes room air conditioners, stationary air conditioning systems for cooling entire buildings or large halls and heat-pump systems.

4.7.1.2.5.1 Room air conditioners

Room air conditioners are used to cool the interiors of individual rooms or even of entire floors. Their performance levels tend to be lower than those of large air conditioning systems. The refrigerants used include the HFC mixture R407C (since 1998) and the mixture R410A (since 1999).

There is no domestic production of room air conditioners. Room air conditioners are normally already filled when imported. "VRF multi-split" units, with 7 internal units, and multi-split units with power ratings of up to 15 kW, and with 3 internal units, are an exception. In 1998, the first devices with R407C appeared on the market, while the first devices with R410A appeared in 2000. Prior to that time, only devices with CFC-22 had been available.

The following refrigeration model is used in this category:

- *Room air-conditioners* are divided into the following five categories, and annual sales in each category are determined via surveys of sellers: mobile units, single-split units, multi-split units with power ratings of 12 kW and of 15 kW, and VRF multi-split systems.

- The pertinent fill amounts and refrigerant mixtures are determined for each category. The annual new consumption, which is identical with annual new additions of refrigerants, is obtained from sales statistics and the above assumptions. When one knows the existing stocks, one can calculate the average yearly stocks and the year-end stocks.
- No production emissions occur. Losses in installation of stationary single-split units are not taken into account, because they represent only very small quantities within the model. The situation is different with regard to multi-split units and VRF multi-split systems. According to surveys of experts, the installation losses amount to 5 g per indoor unit, which translates into an emission factor of 2.5% per indoor unit.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2008, following an average-lifetime period of 10 years. They are calculated with Equation 3. The estimated lifetime is at the lower end of the range given in IPCC-GPG (2000), 10 to 15 years.

Emission factors

Ongoing HFC emissions from room air conditioners are estimated to be 2.5%, for all unit types (mobile, single-split, multi-split (12 KW), multi-split (15 KW), and VRF multi-split), unit sizes and refrigerant types. The emission factor for use thus lies within the middle of the range proposed in IPCC-GPG (2000), 1 to 5 %.

The emission factor for disposal, $EF_{\text{disposal}} = 30 \%$, lies in the upper part of the range proposed in IPCC-GPG (2000), 20 to 30 %.

The country-specific emission factor for production, $EF_{\text{production}} = 2.5 \%$, lies above the value range proposed in IPCC-GPG (2000), 0.2 to 1 %.

The emission factors used are the result of surveys of experts.

4.7.1.2.5.2 *Large air conditioning systems*

In turbocompressor systems, only HFC-134a has been used since 1993. In the years 1995 through 1998, HFC-134a was also used for conversions of CFC-12 turbocompressor systems. In screw compressor systems, HFC-134a has been used since 1993. Since 1997, the refrigerant mixture R407C has been increasingly used as well. From 1995, through 2004, scroll and piston compressor systems used HFC-134a. Since 1997, the refrigerant mixture R407C has been used in such systems; since 2005, R410A has been used as well.

The following refrigeration model is applied:

- Stationary air conditioning systems are divided into three categories. The number of new systems in each of the following categories is determined each year via surveys of experts: turbocompressor systems for the upper performance range, screw compressors for the middle performance range and scroll and piston compressors for the lower performance range (to 20 kW). In cases in which less cooling power is required, room air conditioners are normally used.
- A specific fill amount and specific refrigerant composition are assumed for each category.

- Figures for annual consumption of refrigerant are obtained from the new additions of systems, in connection with the above assumptions. Consumption for CFC replacements in old systems has to be taken into account. HFC additions to domestic stocks are then obtained by subtracting production emissions, which tend to be low in general for refrigeration systems.
- When one knows the existing stocks, one can calculate the average yearly stocks and the year-end stocks.
- Production emissions are calculated by multiplying the quantities used in consumption by the $EF_{\text{production}}$.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2005. They are calculated with Equation 3.

IPCC-GPG (2000) gives a service lifetime of 10 to 30 years for liquid chiller systems. The values used in the present case lie within that range: 12 years for systems with piston and scroll compressors, 20 years for systems with screw compressors and 25 years for turbocompressor systems. The average lifetime of converted CFC-12 turbocompressor systems is estimated at 10 years.

Emission factors

The emission factors used are the result of surveys of experts.

Ongoing HFC emissions are placed at 6%, for all refrigeration-performance classes, compressor types, age classes and refrigerant types. That emissions figure lies within the lower range of the relevant proposal in IPCC-GPG (2000).

The filling loss, at 1 %, lies within the upper section of value range given by IPCC-GPG (2000).

The country-specific emission factor used for disposal, $EF_{\text{disposal}} = 30 \%$, is higher than the range proposed in IPCC-GPG (2000), 5 to 20 %.

Activity data

Due to a lack of publicly accessible statistics on annual HFC consumption for stationary air conditioning systems, of various types, all data for this application must be obtained via surveys of experts, covering the full spectrum from the global market leader to regional firms specialising in air conditioning systems.

4.7.1.2.5.3 Heat pump systems

Via a refrigeration cycle, heat pumps draw heat from the air, ground or groundwater and make it available for heating or cooling indoor areas or for heating water. Since 1995, the refrigerant HFC-134a and the HFC mixtures R404A and R407C have been used; since 1998, R410A has been used as well.

A pertinent refrigerant model, developed with the help of experts, assigns mean HFC fill quantities, and percentage shares of the various HFC types, to the four heat-pump categories of "air", "groundwater", "ground" and "hot water". It also includes service-life and emissions-rate figures. The Bundesverband Wärmepumpe (BWP) national heat-pump industry association publishes annual statistics on the number of new pump units installed within the country. Those data provide the basis for emissions calculation.

Heat pumps with HFCs have been produced and sold since 1995. Since the units have an average service life of 15 years, disposal-related emissions will not occur until 2010.

Emission factors

The emission factors used are the result of surveys of experts.

The current HFC emissions for heating-system heat pumps (air, groundwater and ground systems) are estimated at 2.5 %, while the emissions for water-heating heat pumps are placed at 2 %. The EF_{use} used thus lie within the range proposed by IPCC-GPG (2000).

The filling losses amount to 2 g / heat pump. For the four types of heat pumps involved, with fill quantities ranging from 0.8 kg (water-heating heat pump) to 3 kg (heating-system heat pump working with air), the losses thus range from 0.07 to 0.25 %. Consequently, the $EF_{\text{production}}$ is smaller than, or lies within the lower part of, the range given in IPCC-GPG (2000), 0.2 to 1 %.

The emission factor for disposal, $EF_{\text{disposal}} = 30 \%$, lies in the upper part of the range proposed in IPCC-GPG (2000), 20 to 30 %.

Activity data

Each year, the Bundesverband Wärmepumpe (BWP) national heat-pump association publishes the numbers of new domestic installations of heat pumps. Those figures serve as the basis for the relevant emissions calculation.

4.7.1.2.6 Mobile air conditioning systems (2.F.1.f)

"Mobile air conditioning systems" comprises vehicle air conditioning systems in passenger cars, trucks and utility vehicles, busses, agricultural machinery, rail vehicles and ships. Hydrofluorocarbons (HFCs) have been used in mobile air conditioning systems since 1993. HFC-134a is now the only HFC-based refrigerant used in such systems. Since the 2002 report year, less significant sources (such as agricultural machinery) have been included for the first time.

The time series show a significant emissions increase since 1995. This increase, which has occurred in spite of decreases in fill amounts, is a direct result of increased use of mobile air conditioning systems in vehicles.

We have applied our own refrigeration model, which is as follows:

- Determination of annual numbers of newly licensed vehicles, for the classes automobiles, trucks / utility vehicles, busses and agricultural machines.
- Determination of the average rates of installation of air conditioners in automobiles, trucks / utility vehicles, busses and agricultural machines. For automobiles, the average rate is based on figures for each vehicle type; these are supplemented as appropriate with figures of industry experts.
- Determination of the average fill amounts (refrigerant), from figures for each vehicle type and from figures provided by industry experts.
- Determination of numbers of air conditioning systems newly installed each year on ships (on the basis of statistics on new ship construction for the German fleet) and in railway vehicles (on the basis of new procurements by German Railways / Deutsche Bahn), and determination of the relevant fill amounts involved.

- Determination of annual new additions of HFC-134a for each area, using the above information, and determination of the final stocks and average stocks for each area.
- Emissions from stocks are obtained by multiplying the "average yearly stocks", for each area, by the relevant EF_{use} . Determination of domestic consumption of HFC-134a for production of mobile air conditioning systems.
- Production emissions are computed with Equation 1.
- Disposal emissions occurred for the first time in 2003. These are calculated via Equation 3.

Emission factors

The emission factors used were obtained from the literature (e.g. CLODIC & YAHIA, 1997; FISCHER, 1997; ÖKO-RECHERCHE, 2001; ÖKO-RECHERCHE / ECOFYS 2003; PREISEGGER, 1999; SIEGL et al., 2002), as well as from measurements (automobiles), evaluations of workshop documentation and comprehensive surveys of experts. In addition to regular emissions during operation, emissions also arise as a result of accidents and other external influences.

The EF for filling is half as large as that given in IPCC-GPG (2000: p. 7.52).

The emission factor for disposal of HFC from mobile air conditioners is 0.3. It is thus now in line with the standard value in the IPCC-Guidelines (IPCC 1996b: p. 2.57).

Activity data

New registrations are reported by the Federal Motor Transport Authority.

Fill amounts for automobile air conditioners are determined via direct surveys of automobile companies. In addition, they are obtained by combining official statistics, information from surveys of automakers and experts' assessments (ÖKO-RECHERCHE, 2005).

4.7.1.3 Uncertainties and time-series consistency (2.F.1 all)

The emission factors are subject to considerable uncertainties. The broad range of emission factors found in the literature (see the refrigeration models) for identical applications is only partly a consequence of technical modifications, of how well systems are sealed or of national differences. To a large extent, it also results from real uncertainties, since too little solid empirical study of such factors has been carried out (ÖKO-RECHERCHE, 2007).

As a result of the aforementioned uncertainty with regard to emission factors, and to the large number of individual applications (systems) involved, the emissions data are considered to be too imprecise. In order to improve the reliability of data provided, the data were compared with manufacturers' (substance-oriented) sales data.

Until the 2001 report year, Germany reported only aggregated emissions, covering all sub-source categories. Within the context of emissions surveys for the years 1999 to 2001, and the emissions survey for the 2002 report year, the emissions for the report years 1995 to 1998 were reviewed and updated on the basis of new findings on input quantities and emission factors. All data are thus being improved on an ongoing basis.

The quality of the data on emissions from mobile air conditioning systems is quite good; in fact, it is better than that of the data on emissions from refrigeration systems and stationary air conditioning systems. The reason for this is that annual HFC consumption can be

precisely determined via statistics on new registrations, and on production, imports and exports, of automobiles, which account for the largest part of this sector, as well as via annual model-specific figures on installation rates and the pertinent fill amounts. Only in the area of commercial vehicles are the data subject to major uncertainties.

The emission factors previously assumed have been confirmed via the results of an expert report by the Federal Environment Agency (UBA) and an EU study on leakage rates from mobile air conditioning systems (ÖKO-RECHERCHE / ECOFYS, 2003). Overall, the EF are considered to be accurate.

The uncertainties for the entire sub- source category of refrigeration and air conditioning systems have been quantified for the 2011 report.

4.7.1.4 Source-specific recalculations (2.F.1 all)

For household air conditioning units, the average lifetime was reduced from 18 to 15 years, which lies within the upper section of the value range given in IPCC–GPG (2000) in Table 3.22. This made it necessary to recalculate the disposal emissions, and the recalculations raised the activity data for disposal from 0 t to 2 t, and the disposal emissions from 0 t to 0.6 t, in 2008.

New findings made it necessary to increase the new additions of HFC-134a in household air conditioning systems in 2008 from 2 t to 4 t. In that report year, a recalculation was required because 2 t of removals from stocks had not previously been taken into account. As a result, the higher additions had no effect on the activity data for use and on the emissions from use.

In the area of refrigerated containers, the number of containers produced worldwide in 2008 had to be upwardly corrected, in keeping with new statistical surveys, from 103,000 to 115,000 units. That change, in turn, made it necessary to recalculate the activity data for use, and the emissions from use, for 2008. That recalculation led to an increase in the activity data for use, from 521.48 t to 524.84 t, and to an increase in use emissions from 52.15 t to 52.48 t.

In the area of large stationary air conditioning systems, the numbers of converted turbocompressor systems that had to be disposed of in the years 2005 through 2008 had to be corrected. That correction was required as a result of an error in the calculation procedure whereby calculations were being carried out using different average system lifetimes. The system lifetime for converted CFC-12 systems is now 10 years for all relevant systems. In addition, the corrections made it necessary to recalculate the emissions data for use of, and disposal of, the substance HFC-134a as of 2005. That recalculation led to the changes listed in the following table.

Table 102: Overview of recalculation-related changes in activity data (AD) and emissions (EM) for use and disposal of HFC-134a in large stationary air conditioners in source category 2.F.1.e.

	Units	2005	2006	2007	2008
AD stocks					
Resubmission 2010	t	2,245.90	2,390.20	2,485.43	2,560.25
Submission 2011	t	2,233.40	2,352.70	2,435.43	2,510.25
Difference	t	- 12.50	- 37.50	- 50.00	- 50.00
EM stocks					
Resubmission 2010	t	134.75	143.41	149.13	153.62
Submission 2011	t	134.00	141.16	146.13	150.62
Difference	t	- 0.75	- 2.25	- 3.00	- 3.00
AD disposal					
Resubmission 2010	t	12.50	52.50	81.34	81.34
Submission 2011	t	50.00	100.00	111.34	111.34
Difference	t	+ 37.50	+ 47.50	+ 30.00	+ 30.00
EM disposal					
Resubmission 2010	t	3.75	15.75	24.40	24.40
Submission 2011	t	15.00	30.00	33.40	33.40
Difference	t	+ 11.25	+ 14.25	+ 9.00	+ 9.00

Installation of a calculation procedure for heat pumps in the CSE led to changes, as shown in Table 103, in emissions data for production and use of HFC-125, HFC-134a, HFC-143a and HFC-32 for the years 1995 through 2008. The differences are due to past rounding errors made in manual data entry. Erroneous values for the activity data for use of HFC-134a had been entered for the years 1995 through 2008 and have since been corrected. Furthermore, the EF_{use} for heating-system heat pumps (groundwater and ground systems) that use the refrigerant HFC-134a has been corrected from 2 % to 2.5 %, and that correction led to an increase in emissions from stocks in the years 1995 through 2008.

Implementation of a calculation procedure for bus air conditioning systems in the CSE led to the changes shown in Table 104 in emissions data for production, use and disposal for the years 1993 through 2008. The differences are due to past rounding errors made in manual data entry.

A calculation procedure was also installed for air conditioning systems in agricultural machinery. That procedure led to the changes shown in Table 105 in emissions data for production, use and disposal in the years 1994 through 2008. Here as well, the differences with respect to the Submission 2010 are due primarily to past rounding errors made in connection with manual data entry. Furthermore, an erroneously entered figure for the number of agricultural machines produced in 1994 had to be downwardly corrected. That change led to a reduction in the relevant activity data and emissions for production. In addition, the number of agricultural tractors produced domestically in 2008 was downwardly corrected, on the basis of new statistical surveys, from 69,000 to 65,500 units. Consequently, the activity data for production, and the filling emissions, for 2008 had to be recalculated.

Recalculations had to be carried out to take account of new findings in the area of ship air conditioning systems. Corrections were required in the area of production of ship air conditioning systems, since air conditioned marine vessels have also been produced in Germany as of 2002. The fill quantity for air conditioning systems of domestically produced ocean-going ships was increased, for the years 1997 through 2007, from 150 kg to 220 kg. This was done to take account of the fact that, in addition to ocean-going freighters, with average fill quantities of 150 kg, ocean-going passenger ships, with average fill quantities of 500 kg, were domestically produced (the relevant production ratio was 4:1). The 2008 statistics prepared by the German Shipbuilding and Ocean Industries Association (Verband

für Schiffbau und Meerestechnik e.V.) differentiate, for the first time in such statistics, between different types of domestically produced ocean-going ships. For this reason, the fill quantity for air conditioning systems of ocean-going passenger ships produced in 2008 was corrected from 150 kg to 500 kg.

For the years 2002, 2003 and 2005 through 2008, the activity data for use shows discrepancies with relevant values reported to date. This is the result of implementation of a calculation procedure for ship air conditioning systems that made it possible to correct rounding errors made in the past during manual data entry. The $EF_{\text{use}} = 5\%$ for ship air conditioning systems is no longer used, since the air conditioning systems found on different ship types differ widely in terms of their size and have specific loss rates. For inland-waterway ships, the emission factor for use is 1 %; for ocean-going passenger ships, cruise ships and naval ships, an emission factor for use of 2 % is used; and the emission factor for use on ocean-going freighters is estimated to be 3%. As a result of use of the new emission factors, the use emissions for the years 1997 through 2008 show discrepancies with previously reported values. Recalculations for ship air conditioning systems led to the changes listed in Table 106 in emissions data for production and use, in the years 1997 through 2008.

Installation of a calculation procedure for utility-vehicle air conditioning systems in the CSE led to the changes shown in Table 107 in emissions data for production, use and disposal for the years 1993 through 2008. The differences are due to past rounding errors made in manual data entry.

Implementation in the CSE of a calculation procedure for air conditioning systems in railway vehicles led to changes in production emissions, and in the activity data for use, for the years 1992 through 2008. The changes resulted in that rounding errors were made in the past in manual data entry. The emission factor for use was brought into line with the results of an EU study on mobile air conditioning systems. It now has a value of 6%. That change, in turn, necessitated recalculations of emissions from use for the years 1992 through 2008. All of the changes are shown in Table 108.

Table 103: Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production and use of HFC-125, HFC-134a, HFC-143a and HFC-32 in heat pumps in source category 2.F.1.e.

	Units	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AD production, HFC-125															
Resubmission 2010	t	0.7655	0.8443	1.2020	2.1632	2.5993	3.4443	5.1936	5.2294	6.4773		13.6708		33.7270	
Submission 2011	t	0.7660	0.8447	1.2022	2.1636	2.5995	3.4440	5.1944	5.2291	6.1539		13.6709		33.7446	
Difference	t	+ 0.0005	+ 0.0004	+ 0.0002	+ 0.0003	+ 0.0003	- 0.0003	+ 0.0008	- 0.0002	- 0.3234		+ 0.0001		+ 0.0176	
AD production, HFC-134a															
Resubmission 2010	t	3.4034	3.7210	4.6817	5.7063		8.09634	10.5120	10.2209	11.1506		14.4369	41.3962		
Submission 2011	t	3.4037	3.7210	4.6820	5.7066		8.09625	10.5129	10.2211	10.6745		14.4373	41.3967		
Difference	t	+ 0.0003	+ 0.0001	+ 0.0003	+ 0.0003		- 0.0001	+ 0.0009	+ 0.0002	- 0.4760		+ 0.0004	+ 0.0005		
AD production, HFC-143a															
Resubmission 2010	t	0.5093	0.5293	0.7335	0.7425		1.0865	1.6648	1.6413	2.3969			11.9192		
Submission 2011	t	0.5096	0.5297	0.7337	0.7426		1.0863	1.6651	1.6411	2.3627			11.9194		
Difference	t	+ 0.0003	+ 0.0003	+ 0.0002	+ 0.0001		- 0.0002	+ 0.0004	- 0.0002	- 0.0342			- 0.0002		
AD production, HFC-32															
Resubmission 2010	t	0.3078	0.3646	0.5348	1.4593	1.7714	2.3830	3.5664		4.1863		9.6254	20.8157	20.7056	
Submission 2011	t	0.3080	0.3648	0.5349	1.4595	1.7717	2.3829	3.5669		3.9076		9.6255	20.8159	20.7232	
Difference	t	+ 0.0002	+ 0.0001	+ 0.0001	+ 0.0002	+ 0.0002	- 0.0001	+ 0.0005		- 0.2787		+ 0.0001	+ 0.0002	+ 0.0176	
EM production, HFC-125															
Resubmission 2010	t	0.0005	0.0005	0.0007	0.0016	0.0018	0.0023	0.0035	0.0035	0.0058					
Submission 2011	t	0.0006	0.0007	0.0010	0.0020	0.0024	0.0032	0.0048	0.0049	0.0055					
Difference	t	+ 0.0001	+ 0.0002	+ 0.0003	+ 0.0004	+ 0.0006	+ 0.0009	+ 0.0013	+ 0.0013	- 0.0003					
EM production, HFC-134a															
Resubmission 2010	t	0.0067	0.0072	0.0087	0.0096	0.0106	0.0119	0.0136	0.0127	0.0158					
Submission 2011	t	0.0070	0.0076	0.0092	0.0105	0.0119	0.0137	0.0163	0.0155	0.0153					
Difference	t	+ 0.0003	+ 0.0004	+ 0.0005	+ 0.0009	+ 0.0012	+ 0.0018	+ 0.0027	+ 0.0028	- 0.0005					
EM production, HFC-32															
Resubmission 2010	t	0.0001	0.0002	0.0002	0.0010	0.0012	0.0016	0.0023	0.0024	0.0041					
Submission 2011	t	0.0003	0.0003	0.0005	0.0014	0.0018	0.0024	0.0035	0.0036	0.0038					
Difference	t	+ 0.0001	+ 0.0002	+ 0.0002	+ 0.0004	+ 0.0005	+ 0.0008	+ 0.0012	+ 0.0012	- 0.0003					
AD use, HFC-125															
Resubmission 2010	t	0.3828	1.1877	2.2108	3.8934	6.2747	9.2965	13.6154	18.8269	24.6810	31.6819	42.2803	65.1765	98.1088	139.4584
Submission 2011	t	0.3830	1.1883	2.2118	3.8947	6.2762	9.2980	13.6172	18.8290	24.5205	31.3605	41.9589	64.8547	97.7874	139.1370
Difference	t	+ 0.0002	+ 0.0007	+ 0.0010	+ 0.0013	+ 0.0016	+ 0.0015	+ 0.0018	+ 0.0021	- 0.1605	- 0.3214	- 0.3214	- 0.3217	- 0.3214	- 0.3214
AD use, HFC-134a															
Resubmission 2010	t	1.7017	3.9298	5.3690	7.4270	10.0469	13.5838	18.7405	24.5944	30.7574	38.1499	47.3912	70.7663	105.4816	202.3579
Submission 2011	t	1.7019	5.2643	9.4657	14.6600	20.8288	28.1924	37.4970	47.8640	58.3118	69.7073	82.9840	110.9010	152.5777	201.8839
Difference	t	+ 0.0001	+ 1.3345	+ 4.0967	+ 7.2330	+ 10.782	+ 14.609	+ 18.757	+ 23.270	+ 27.554	+ 31.557	+ 35.593	+ 40.135	+ 47.096	- 0.4741
AD use, HFC-143a															
Resubmission 2010	t	0.2547	0.7740	1.4054	2.1434	2.9449	3.9184	5.2940	6.9471	8.9662	11.5408	15.1040	23.2508	36.1670	56.2287
Submission 2011	t	0.2548	0.7745	1.4061	2.1443	2.9458	3.9192	5.2949	6.9480	8.9499	11.5075	15.0707	23.2172	36.1336	56.1954
Difference	t	+ 0.0002	+ 0.0005	+ 0.0007	+ 0.0009	+ 0.0010	+ 0.0009	+ 0.0009	+ 0.0010	- 0.0162	- 0.0333	- 0.0333	- 0.0335	- 0.0333	- 0.0333

	Units	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AD use, HFC-32															
Resubmission 2010	t	0.1539	0.4901	0.9399	1.9370	3.5523	5.6296	8.6043	12.1973	16.1009	20.6386	27.8966	43.1175	63.8869	86.8932
Submission 2011	t	0.1540	0.4904	0.9402	1.9374	3.5530	5.6303	8.6052	12.1984	15.9619	20.3610	27.6191	42.83985	63.6093	86.6156
Difference	t	+ 0.0001	+ 0.0002	+ 0.0003	+ 0.0005	+ 0.0007	+ 0.0008	+ 0.0009	+ 0.0012	- 0.1389	- 0.2776	- 0.2776	- 0.2777	- 0.2776	- 0.2776
EM use, HFC-125															
Resubmission 2010	t								0.47067	0.6170	0.7920	1.0570	1.6294	2.4527	3.4865
Submission 2011	t								0.47072	0.6130	0.7840	1.0490	1.6214	2.4447	3.4784
Difference	t								+ 0.0001	- 0.0040	- 0.0080	- 0.0080	- 0.0080	- 0.0080	- 0.0080
EM use, HFC-134a															
Resubmission 2010	t	0.0359	0.1111	0.2005	0.3126	0.4477	0.6110	0.8211	1.0576	1.3029	1.5742	1.8834	2.5465	3.5454	4.7171
Submission 2011	t	0.0363	0.1125	0.2031	0.3169	0.4541	0.6197	0.8328	1.0729	1.3166	1.5855	1.9002	2.5732	3.5853	4.7715
Difference	t	+ 0.0005	+ 0.0014	+ 0.0026	+ 0.0044	+ 0.0064	+ 0.0087	+ 0.0117	+ 0.0153	+ 0.0137	+ 0.0113	+ 0.0168	+ 0.0267	+ 0.0398	+ 0.0544
EM use, HFC-143a															
Resubmission 2010	t									0.2242	0.2885	0.3776	0.5813	0.9042	1.4057
Submission 2011	t									0.2237	0.2877	0.3768	0.5804	0.9033	1.4049
Difference	t									- 0.0004	- 0.0008	- 0.0008	- 0.0008	- 0.0008	- 0.0008
EM use, HFC-32															
Resubmission 2010	t									0.4025	0.5160	0.6974	1.0779	1.5972	2.1723
Submission 2011	t									0.3990	0.5090	0.6905	1.0710	1.5902	2.1654
Difference	t									- 0.0034	- 0.0069	- 0.0069	- 0.0069	- 0.0069	- 0.0069

Table 104: Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production, use and disposal of HFC-134a in bus air conditioners in source category 2.F.1.f.

	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AD production																	
Resubmission 2010	t			57.800	65.200	78.100	93.500	89.400	105.800	89.400	77.400	91.080	84.360	75.300	79.600		
Submission 2011	t			58.141	64.603	77.744	93.492	89.397	105.440	89.598	77.434	91.076	84.365	75.330	79.615		
Difference	t			+ 0.341	- 0.597	- 0.356	- 0.008	- 0.003	- 0.360	+ 0.198	+ 0.034	- 0.004	+ 0.005	+ 0.030	+ 0.015		
AD use																	
Resubmission 2010	t		49.26	80.99	120.64	168.75	213.74	258.53	307.23	355.00	400.70	442.70	479.30	503.29	518.33	535.42	552.29
Submission 2011	t		49.13	80.82	120.39	168.25	213.16	257.94	306.57	354.28	400.03	442.10	478.67	502.64	517.82	534.95	551.89
Difference	t		- 0.13	- 0.18	- 0.26	- 0.51	- 0.58	- 0.58	- 0.66	- 0.72	- 0.67	- 0.60	- 0.63	- 0.65	- 0.51	- 0.47	- 0.39
EM use																	
Resubmission 2010	t	2.50	7.40	12.10	18.10	25.30	32.10	38.80	46.10	53.20	60.10	66.40	71.90	75.50	77.80	80.30	82.84
Submission 2011	t	2.49	7.37	12.12	18.06	25.24	31.97	38.69	45.99	53.14	60.01	66.31	71.80	75.40	77.67	80.24	82.78
Difference	t	- 0.01	- 0.03	+ 0.02	- 0.04	- 0.06	- 0.13	- 0.11	- 0.11	- 0.06	- 0.09	- 0.09	- 0.10	- 0.10	- 0.13	- 0.06	- 0.06
AD disposal																	
Resubmission 2010	t														32.18	31.29	37.00
Submission 2011	t														31.91	31.47	36.67
Difference	t														- 0.27	+ 0.18	- 0.34
EM disposal																	
Resubmission 2010	t														9.65	9.39	11.10
Submission 2011	t														9.57	9.44	11.00
Difference	t														- 0.08	+ 0.05	- 0.10

Table 105: Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production, use and disposal of HFC-134a in agricultural-machinery air conditioning systems in source category 2.F.1.f.

	Units	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AD production																
Resubmission 2010	t	19.000	23.800	30.100	31.000	35.100	36.800	42.000	47.400	59.700	67.930	80.960	89.572	86.320		116.763
Submission 2011	t	4.560	23.693	30.482	31.148	35.087	36.663	42.299	47.641	59.257	67.745	81.386	89.795	86.324		111.890
Difference	t	- 14.440	- 0.107	+ 0.382	+ 0.148	- 0.013	- 0.137	+ 0.299	+ 0.241	- 0.443	- 0.185	+ 0.426	+ 0.223	+ 0.004		- 4.873
EM production																
Resubmission 2010	t	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.200	0.200	0.200	0.300	0.300	0.300		0.373
Submission 2011	t	0.014	0.081	0.104	0.106	0.120	0.126	0.145	0.164	0.204	0.231	0.279	0.308	0.296		0.357
Difference	t	- 0.086	- 0.019	+ 0.004	+ 0.006	+ 0.020	+ 0.026	+ 0.045	- 0.036	+ 0.004	+ 0.031	- 0.021	+ 0.008	- 0.004		- 0.016
AD use																
Resubmission 2010	t		17.924	32.583	49.699	69.673	92.011	115.413	140.880	169.758	200.062	226.350	250.917	277.460	301.509	325.889
Submission 2011	t		17.894	32.614	49.877	69.909	92.212	115.666	141.274	169.988	200.029	226.367	251.342	277.645	301.542	325.865
Difference	t		- 0.030	+ 0.031	+ 0.178	+ 0.236	+ 0.201	+ 0.252	+ 0.394	+ 0.230	- 0.033	+ 0.017	+ 0.425	+ 0.185	+ 0.033	- 0.024
EM use																
Resubmission 2010	t	0.900	2.800	5.900	9.000	12.500	16.300	20.200	24.400	29.200	34.200	38.300	41.900	45.900	49.500	53.021
Submission 2011	t	1.050	3.304	5.942	8.995	12.506	16.313	20.240	24.505	29.249	34.169	38.278	41.984	45.912	49.424	52.977
Difference	t	+ 0.150	+ 0.504	+ 0.042	- 0.005	+ 0.006	+ 0.013	+ 0.040	+ 0.105	+ 0.049	- 0.031	- 0.022	+ 0.084	+ 0.012	- 0.076	- 0.043
AD disposal																
Resubmission 2010	t												13.288	16.031	18.200	
Submission 2011	t												13.299	16.211	18.315	
Difference	t												- 0.059	+ 0.180	+ 0.116	
EM disposal																
Resubmission 2010	t												3.986	4.810	5.460	
Submission 2011	t												3.969	4.863	5.495	
Difference	t												- 0.018	+ 0.053	+ 0.035	

Table 106: Overview of recalculation-related changes in activity data (AD), emission factors (EF) and emissions (EM) for production and use of HFC-134a in ship air conditioning systems in source category 2.F.1.f.

	Units	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AD production													
Resubmission 2010	t	11.100	10.850	9.350	8.650	9.650	9.400	9.100	9.550	12.800	14.200	16.050	16.100
Submission 2011	t	20.220	19.610	15.830	14.530	15.410	16.740	15.990	16.560	18.030	21.710	21.090	23.100
Difference	t	+ 9.120	+ 8.760	+ 6.480	+ 5.880	+ 5.760	+ 7.340	+ 6.890	+ 7.010	+ 5.230	+ 7.510	+ 5.040	+ 7.000
EM production													
Resubmission 2010	t	0.111	0.109	0.094	0.087	0.097	0.094	0.091	0.096	0.128	0.142	0.1605	0.161
Submission 2011	t	0.202	0.196	0.158	0.145	0.154	0.167	0.160	0.166	0.180	0.217	0.211	0.231
Difference	t	+ 0.091	+ 0.088	+ 0.065	+ 0.059	+ 0.058	+ 0.073	+ 0.069	+ 0.070	+ 0.052	+ 0.075	+ 0.050	+ 0.070
AD use													
Resubmission 2010	t						31.475	38.350		55.050	63.950	72.625	85.775
Submission 2011	t						31.100	37.975		55.200	64.375	73.175	86.325
Difference	t						- 0.375	- 0.375		+ 0.150	+ 0.425	+ 0.550	+ 0.550
EF use													
Ships, Resubmission 2010	%	5	5	5	5	5	5	5	5	5	5	5	5
Inland-waterway ships, Submission 2011	%	1	1	1	1	1	1	1	1	1	1	1	1
Ocean-going freighters, Submission 2011	%	3	3	3	3	3	3	3	3	3	3	3	3
Other ocean-going ships, Submission 2011	%	2	2	2	2	2	2	2	2	2	2	2	2
Difference	%	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80	- 40 - 80
EM use													
Resubmission 2010	t	0.700	1.600	2.500	4.100	5.800	7.600	9.400	11.500	13.800	16.100	18.400	22.700
Submission 2011	t	0.570	1.763	3.028	4.303	5.623	6.990	8.505	10.265	12.168	14.143	16.095	19.430
Difference	t	- 0.130	+ 0.163	+ 0.528	+ 0.203	- 0.177	- 0.610	- 0.895	- 1.235	- 1.633	- 1.958	- 2.305	- 3.270

Table 107: Overview of recalculation-related changes in activity data (AD) and emissions (EM) for production, use and disposal of HFC-134a in utility-vehicle air conditioning systems in source category 2.F.1.f.

	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AD production																	
Resubmission 2010	t	5.500	19.700	44.971	46.681	71.686	101.089	115.803	131.235	145.162	143.972	164.900	204.100	220.600	246.100	282.634	298.081
Submission 2011	t	5.332	20.091	44.865	46.414	72.104	100.993	112.225	128.713	140.508	139.305	159.558	201.163	219.310	247.019	286.605	300.034
Difference	t	-0.168	+0.391	-0.107	-0.268	+0.419	-0.096	-3.578	-2.522	-4.654	-4.667	-5.232	-2.937	-1.290	+0.919	+3.970	+1.953
EM production																	
Resubmission 2010	t	0	0	0.100	0.100	0.100	0.200	0.200	0.200	0.300	0.300	0.300	0.400	0.400	0.460	0.540	0.584
Submission 2011	t	0.010	0.036	0.079	0.084	0.132	0.185	0.205	0.234	0.259	0.259	0.299	0.374	0.409	0.467	0.550	0.592
Difference	t	+0.010	+0.036	-0.021	-0.016	+0.032	-0.015	+0.005	+0.034	-0.041	-0.041	-0.001	-0.026	+0.009	+0.007	+0.010	+0.008
AD use																	
Resubmission 2010	t	2.700	11.000	30.100	56.700	90.900	140.000	206.000	281.100	358.700	436.200	514.900	601.300	691.300	791.600	905.100	1012.370
Submission 2011	t	2.209	11.162	30.324	57.078	91.645	140.897	206.473	281.218	358.410	434.880	512.397	597.856	687.318	787.571	901.379	1009.072
Difference	t	-0.491	+0.162	+0.224	+0.378	+0.745	+0.897	+0.473	+0.118	-0.290	-0.320	-2.503	-3.444	-3.982	-4.029	-3.721	-3.297
EM use																	
Resubmission 2010	t	0.300		4.100	7.800	12.400	19.000	28.000	38.300	48.900	59.200	69.600	80.800	92.500	105.100	119.300	132.539
Submission 2011	t	0.296		4.137	7.822	12.503	19.141	28.072	38.334	48.860	59.105	69.343	80.530	92.087	104.745	119.002	132.257
Difference	t	-0.004		+0.037	+0.022	+0.103	+0.141	+0.072	+0.034	-0.040	-0.095	-0.257	-0.270	-0.413	-0.355	-0.298	-0.281
AD disposal																	
Resubmission 2010	t											4.514	13.196	24.753	28.507	39.918	58.145
Submission 2011	t											4.418	13.489	24.833	28.676	40.457	58.046
Difference	t											-0.096	+0.293	+0.080	+0.1639	+0.539	-0.099
EM disposal																	
Resubmission 2010	t											1.354	3.959	7.426	8.552	11.976	17.443
Submission 2011	t											1.325	4.047	7.450	8.603	12.137	17.414
Difference	t											-0.029	+0.088	+0.024	+0.051	+0.162	-0.030

Table 108: Overview of recalculation-related changes in production emissions (EM), and in activity data (AD), emission factors (EF) and emissions (EM) for use of HFC-134a in railway-vehicle air conditioning systems in source category 2.F.1.f.

	Units		1992	1993	1994	1995	1996	1997	1998	1999
EM production										
Resubmission 2010	t		0.0070	0.0130	0.0130				0.0359	0.0300
Submission 2011	t		0.0066	0.0132	0.0132				0.0360	0.0301
Difference	t		- 0.0004	+ 0.0002	+ 0.0002				+ 0.0001	+ 0.0001
AD use										
Resubmission 2010	t		1.6464	6.5856	13.1712	20.9640	31.5600	45.8400	63.0300	79.5500
Submission 2011	t		1.6450	6.5850	13.1750	20.9700	31.5632	45.8411	63.0297	79.5477
Difference	t		- 0.001	- 0.001	+ 0.004	+ 0.006	+ 0.003	+ 0.001	- 0.0003	- 0.002
EF use										
Resubmission 2010	t		0.1215	0.0911	0.0911	0.0954	0.0792	0.0698	0.0714	0.0691
Submission 2011	t		0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Difference	t		- 0.0615	- 0.0311	- 0.0311	- 0.0354	- 0.0192	- 0.0098	- 0.0114	- 0.0091
EM use										
Resubmission 2010	t		0.20	0.60	1.20	2.00	2.50	3.20	4.50	5.50
Submission 2011	t		0.10	0.40	0.79	1.26	1.89	2.75	3.78	4.77
Difference	t		- 0.10	- 0.20	- 0.41	- 0.74	- 0.61	- 0.45	- 0.72	- 0.73
	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008
EM production										
Resubmission 2010	t									
Submission 2011	t									
Difference	t									
AD use										
Resubmission 2010	t	97.8439	121.1144	145.4418	164.2060	177.9253	192.5948	207.9378	217.9140	224.3974
Submission 2011	t	97.8496	121.1201	145.4475	164.2117	177.9310	192.6005	207.9435	217.9197	224.4034
Difference	t	+ 0.006	+ 0.006	+ 0.006	+ 0.006	+ 0.006	+ 0.006	+ 0.006	+ 0.006	+ 0.006
EF use										
Resubmission 2010	t	0.0654	0.0611	0.0605	0.0609	0.0607	0.0607	0.0606	0.0606	0.0606
Submission 2011	t	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Difference	t	- 0.0011	- 0.0005	- 0.0005	- 0.0009	- 0.0007	- 0.0007	- 0.0006	- 0.0006	- 0.0006
EM use										
Resubmission 2010	t	6.40	7.40	8.80	10.00	10.80	11.70	12.60	13.20	13.60
Submission 2011	t	5.87	7.27	8.73	9.85	10.68	11.56	12.48	13.08	13.46
Difference	t	- 0.53	- 0.13	- 0.07	- 0.15	- 0.12	- 0.14	- 0.12	- 0.12	- 0.14

4.7.1.5 Source-specific planned improvements (2.F.1 all)

No improvements are planned at present.

4.7.2 Foam blowing (2.F.2)

Since 1993, hydrofluorocarbons (HFCs) have also been used in foam blowing as substitutes for ozone-depleting, climate-damaging CFCs and HCFCs.

In the national CSE database, the area of foams is divided into hard and soft foams. No HFC blowing agents are needed in soft-foam production, and thus soft foams are not taken into account in the report.

The four categories of hard foam for which HFCs are used as blowing agents include PUR hard foam, PUR integral foam, PUR foam sealant (one-component foam – OCF) and XPS insulation foam.

4.7.2.1 PUR foam products (2.F.2)

4.7.2.1.1 Source category description (2.F.2)

The group of PUR foam products includes integral-foam and hard-foam products. Hard foams are used in many different types of products, including household appliances, insulation boards, sandwich elements and insulating foams produced in small series. Integral foams are used in shoes for sports and recreation and in various automobile parts. From 1996 to 1997, HFCs were used only in integral foams. Since 1998, they have also been used as blowing agents in PUR hard foams. HFCs have been giving way to hydrocarbons such as pentane.

The time series, which does not begin until 1996, shows a small initial increase in emissions. Both of these factors – the time of commencement and the small initial increase – agree with the historical development of HFC use in this application area, an area which arose only slowly, as a result of the long period of utilisation of HCFCs.

Along with HFC-134a, since 2002 HFC-365mfc (with small quantities of added HFC-227ea) has also been used as a blowing agent. Since 2004, HFC-245fa has also been used as such an agent. HFC-245ca is not used in Germany.

From 2002 to 2004, HFC-227ea was still used for hard foams and integral foams. Use of HFC-134a in production of PUR hard foams was discontinued in 2004.

4.7.2.1.2 Methodological issues (2.F.2)

Emissions are determined by means of Equation 1 and Equation 2. The production emissions consist of the quantity of HFC emitted within no more than one year after production (first-year loss).

Emission factors

The emission factors used are shown in Table 101. In the case of PUR hard foams with HFC-134a, the factors are in line with the standard values given in IPCC-GPG (2000). The emission factors for all other HFCs have been approved by national experts and adjusted where necessary. For example, the emission factor for production of PUR hard foam with use

of 365mfc/245fa was increased from 10 % to 15 %, because that HFC mixture has been used increasingly since 2004 in open on-site applications, especially in spray foams.

The emission factor for HFKW-365mfc from stocks was taken from an estimate based on test products.

In the case of integral foams, all of the blowing agent (apart from small residual amounts) escapes during the foaming process. Since the residual amounts in question escape within no more than 2 years (so the domestic experts who were consulted), an emission factor of 100 % for production is considered suitable for Germany, instead of the value given in IPCC-GPG (2000).

Activity data

The figures for new domestic consumption, for each blowing agent and each product group, are based on the amounts of foam products produced in Germany. The data for products in service are based on the amounts of foam products used in Germany (sales in Germany) since the introduction of HFCs. Given a product lifetime of at least 20 years, removals from products in service do not yet play any significant role.

New domestic consumption and domestic sales of foam products are determined annually via surveys of manufacturers, users and blowing-agent suppliers, and via information from the relevant industry association (IVPU – the polyurethane-foam industry association).

4.7.2.2 PUR foam sealants (2.F.2)

4.7.2.2.1 Source category description (2.F.2)

The term "foam sealant" refers to polyurethane foam that is sprayed, on site, from pressurised containers (cans). The blowing agents now used for such foam, following the prohibition of HCFCs, include mixtures of HFCs and propane, butane or dimethyl ether (DME). At the same time, the HFC quantities in such cans have been continually reduced since 1996.

HFC-134a has been used in Germany since 1992, in production of PUR one-component foam (in cans). HFC-152a was used from 2002 to 2004. Imported PUR one-component foams (in cans) used in Germany contain HFC-134a or HFC-152a. As of 4 July 2008, a ban on placing on the market of one-component foams filled with fluorinated greenhouse gases applies, with just a few exceptions, in the EU. Pertinent emissions can be expected to decrease sharply as a result.

4.7.2.2.2 Methodological issues (2.F.2)

Pursuant to the IPCC Guidelines (1996b: p. 2.58), in each case the emissions for this open use are considered the same as the HFC quantity sold with the can. In contrast to the IPCC method, it is assumed that all emissions occur in the year of sale, however, since use and disposal occur promptly. At the same time, used cans are not completely empty when they go to waste management; they still contain about 8 % of their original foam contents, including the relevant blowing agent. The majority of that blowing agent eventually also enters the atmosphere, after a certain delay.

Filling emissions are calculated from the number of cans filled per year in Germany and the blowing-agent loss per can.

Emissions from use are calculated with Equation 2.

Emission factors

The $EF_{\text{Production}}$ was determined via surveys of experts and of manufacturers. From 1992 to 2002, it amounted to 1.5 g/can, while as of 2003 it has been only 0.5 g/can.

Activity data

The following data are required for determination of new domestic HFC consumption for filling and the resulting filling losses (production emissions):

- Number of cans filled annually, in Germany, with HFC-134a or HFC-152a
- HFC content per can, in grams
- Specific filling loss.

These data are obtained via surveys of experts.

The following information is required for determination of use emissions per year:

- Number of cans with blowing agent 134a or 152a that are sold annually in Germany
- HFC content per can, in grams.

These data are provided by the manufacturers themselves.

The pre-1995 data for foam sealants were obtained via discussion, in 2006, with leading foreign OCF sellers and from older publications.

4.7.2.3 XPS hard foam (2.F.2)

4.7.2.3.1 Source category description (2.F.2)

HFC consumption and emissions from production of XPS insulation boards have occurred only since 2001, since HCFCs or CO₂/ethanol were used in this area prior to that time. HFC-152a and 134a, either by themselves or in mixtures, are used.

4.7.2.3.2 Methodological issues (2.F.2)

Total emissions from this area are calculated with Equation 1 and Equation 2. For both of the HFCs used, the new inland consumption is reported directly by the European association CEFIC⁴⁵ or by its industry group EXIBA⁴⁶.

Trials with HFC collection and recovery have been conducted, but to date no relevant systems have been implemented, for both technical and economic reasons.

Use emissions are calculated from the average amount of HFCs in XPS insulating foams in domestic service. This amount increases annually solely through new addition of insulation boards containing 134a. Given a product lifetime of 50 years, removals from products in service do not yet play any significant role. The new HFC additions are not equivalent to annual new consumption, minus production emissions. The reason for this is that, as a result of foreign trade, especially exports of 134a-based XPS, only 25 % (the complementary value for the export rate) of the HFC-134a contained in products amounts to new additions to domestic HFC stocks.

⁴⁵ CEFIC – The European Chemical Industry Council

⁴⁶ EXIBA – European Extruded Polystyrene Insulation Board Association

Disposal emissions thus play no significant role to date.

Emission factors

The production emissions (HFC first-year losses) for HFC-152a are practically 100 % ($EF_{\text{Production}}$ of HFC-152a = 1), since the substance is used solely as a blowing agent in production. With HFC-134a, only part of consumption is emitted upon blowing; most of the substance enters into the product. The $EF_{\text{Production}}$ for HFC-134a is determined empirically and communicated by the CEFIC⁴⁷ association or by its EXIBA⁴⁸ industry association.

A representative of the FPX extruded-polystyrene-foam association estimated the annual releases from enclosed HFC-134a cell gas as being less than 1 % in 2002. That figure is based, inter alia, on an internal study of BASF regarding the half-lives of various cell gases, including HFC-134a (WEILBACHER 1987). The EF_{Use} from that laboratory study has been used for HFC-134a. Fugitive emissions from boards depend on board thickness, and they can be given only as average values, or as values for specific board thicknesses. As a result, the value given refers to boards of medium thickness.

Activity data

All of the data required for emissions calculation, including new domestic consumption, loss rate in production and the foreign trade balance for HFC-134a-containing insulation boards, are provided by the relevant European industry association (CEFIC or EXIBA).

4.7.2.4 Uncertainties and time-series consistency (2.F.2)

The uncertainties for the "foams" sub- source category have been systematically quantified.

The emissions data for prior years, for PUR foam products, are considered fairly accurate, since the quantities of HFCs used are still rather small at present. In future, however, it will become more difficult to obtain a good market overview in view of the anticipated product diversity.

Because it includes only a small number of manufacturers, the German XPS market is not complex. Since the EF and AD were prepared in co-operation with manufacturers, they are considered sufficiently precise.

Since 2001, the relevant industry association has determined the input quantities of HFC-152a and HFC-134a (AD) in production of XPS hard foams. Since only three manufacturers use HFC for XPS blowing, there is little reason to doubt the reliability of the activity data. This also applies to the export rate and the HFC production emissions determined for use of HFC-134a.

The production emissions in use of HFC-152a, 100 %, do not agree with the existing IPCC estimates. Nonetheless, the industry association considers them to be realistic.

The value for the emissions rate from current stocks, as determined by a laboratory study, will be used as long as no reliable measurements with insulation boards in actual service have been carried out; such measurements would be considered more conclusive than laboratory values.

⁴⁷ CEFIC – The European Chemical Industry Council

⁴⁸ EXIBA – European Extruded Polystyrene Insulation Board Association

4.7.2.5 Source-specific recalculations (2.F.2)

No recalculations are required.

4.7.2.6 Source-specific planned improvements (2.F.2)

No improvements are planned at present.

4.7.3 Fire extinguishers (2.F.3)

4.7.3.1 Source category description (2.F.3)

Halons, which until 1991 were permitted fire extinguishing agents, have since been largely supplanted by ecologically safe substances – especially inert gases, such as nitrogen and argon, for systems for flooding rooms; and by powder, CO₂ and foams in handheld fire extinguishers.

In 1998, HFC-227ea was certified in Germany as a halon substitute. In 2001, HFC 236fa also received such certification. That substance is used solely in the military sector, however. HFC-23, while certified since 2002, did not begin to be used until 2005. Today, certification of fire extinguishing agents is no longer required. Nonetheless, the list of fire extinguishing agents in use has not grown, since all application areas can be covered with halogen-free agents and with the aforementioned HFCs (especially 227ea and 236fa).

HFC-based fire extinguishing agents are imported and filled into fire extinguishing systems in Germany. Virtually no foreign trade with filled systems takes place. The time series do not begin until after 1995.

4.7.3.2 Methodological issues (2.F.3)

The annual new HFC additions in domestic systems are identical with the amounts added to new systems within the country (new HFC consumption).

IPCC-GPG (2000, Chapter 3.7.6) proposes that a "sales-based top-down" approach be used for determining emissions in connection with fire extinguishing agents. A bottom-up Tier-2 approach is considered unsuitable because the activity data required for that approach are unavailable for many countries. Since activity data are available in Germany for HFC-227ea and 236fa, a bottom-up approach is used. Unlike the top-down approach of the IPCC-GPG (2000), the bottom-up approach takes filling emissions into account.

Due to a lack of pertinent data, the installed quantities of HFC 23 are estimated by the Federal Environment Agency.

Pursuant to the *IPCC Guidelines 2006*, fire extinguishing systems have an average service life of 15 years.

Emission factors

The EF_{Production} are based on experts' assessments.

An EF_{Use} is used only for HFC-236fa. That EF, which is based on experts' assessments, increases from 1 % to 5 % by the year 2007, in order to take account of the greater probability of leaks in older systems.

In keeping with the *IPCC Guidelines 2006*, the emission factor for use of HFC-23 is set to 4 % and the emission factor for disposal is set to 100%.

Activity data

The emission figures for HFC 227ea are based on statistical surveys by one company, covering the aspects of input quantities, refill quantities, accidental releases, releases in cases of fire, and flooding tests in Germany (by analogy to Tier 2). As a result, not all of the market is covered, since there are other sellers. This fact is addressed via extrapolation on the basis of market shares as estimated by the company. The data for HFC-236fa are based on company information provided on a voluntary basis. The figures for HFC-23 are based on estimates of the Federal Environment Agency.

4.7.3.3 Uncertainties and time-series consistency (2.F.3)

The uncertainties for the "fire extinguishing agents" sub- source category have been systematically quantified.

4.7.3.4 Source-specific recalculations (2.F.3)

No recalculations are required.

4.7.3.5 Source-specific planned improvements (2.F.3)

No improvements are planned at present.

4.7.4 Aerosols (2.F.4)

This area includes metered-dose inhalers (MDI), which are used in medical applications, as well as general-purpose aerosols and so-called "novelty aerosols".

4.7.4.1 Metered dose inhalers (2.F.4.a)

4.7.4.1.1 Source category description (2.F.4.a)

Metered-dose inhalers are used in the medical sector, primarily for treatment of asthma. Metered-dose inhalers with an HFC propellant first reached the German market in 1996. They contained the propellant HFC-134a. Since then, the number of available preparations has grown continually. Such devices have been filled domestically only since 2001. Since 1999, HFC-227ea has been used in addition to HFC-134a.

The time series shows an emissions increase that correlates with increasing use of HFCs as CFC substitutes. A large change occurred in 2001. As of that year, CFCs were prohibited for the largest group of active ingredients, the short-acting betamimetics.

4.7.4.1.2 Methodological issues (2.F.4.a)

With regard to the activity data, the method is equivalent to a bottom-up approach. Since 98 % of the contents of such inhalers consist of propellant, their contents are considered to consist solely of HFCs.

Most inhalers are sold by chemists (pharmacies). An estimated 10 percent are used by hospitals, for their own needs, while 3 percent are samples, "not for sale", for doctors and pharmaceutical representatives. These two categories are taken into account by adding 13 % to sales by chemists/pharmacies.

The time period between pharmacy sales and use is short. The reference figure for emissions – in contrast to IPCC-GPG (2000, equation 3.35) – is thus not the sum of half the

purchases (sales) of the previous year and half the purchases (sales) of the current year, but all purchases (sales) for the current year. The IPCC-GPG approach would be a useful choice if the available data covered produced inhalers – rather than sold inhalers – since considerable time, for transport and storage, indeed passes between production and use.

The production emissions are added to the usage emissions. Part of the emissions are collected with cold traps and then incinerated. Without such collection, the emissions would be higher.

Emission factors

The $EF_{\text{Production}}$ on which production emissions is based is itself based on very precise producers' data on filling emissions. These amount to about 1 %, with respect to new consumption for filling. This translates to about 0.15 g per 10 ml inhaler.

In agreement with IPCC specifications (IPCC, 1996b, p. 2.61), a 100 % emissions level ($EF_{\text{Use}} = 1$) is assumed. Inhaled HFCs are not broken down in bronchial passages; they are released into the atmosphere, without undergoing any changes, upon exhalation. The inhalers are assumed to have a lifetime of only one year, however. The emission factor has thus been classified as "country-specific".

Activity data

The emissions data for the period until report year 2005 (production) and 2006 (use) are based on sales figures (sales in pharmacies) for metered-dose inhalers in Germany, as obtained via surveys of producers. The total unit numbers, the average fill quantity in ml and the propellant used have all entered into relevant calculations. As of report year 2006, the activity-rate figures for production are based on experts' estimates. As of report year 2007, the activity-rate figures for use are based on such estimates. The surveys of the *Federal Statistical Office* for the area of metered dose inhalers normally do not become available for the corresponding current report year. Retroactive data cross-checking is carried out, however.

4.7.4.2 Other aerosols (2.F.4.b)

4.7.4.2.1 Source category description (2.F.4.b)

In Germany, six types of general-purpose aerosols (includes neither medical sprays nor novelties) containing HFC are sold:

- Compressed-air sprays,
- Cooling sprays,
- Drain-opener sprays,
- Lubricating sprays,
- Insecticides, and
- Self-defence sprays.

Production and use of general-purpose aerosols with HFC-134a began in 1992; production and use of such aerosols with HFC-152a began in 1995. The HFC quantities filled in Germany remained constant from 1995 to 2005. Since 2006, those quantities have been decreasing slightly.

Other aerosols include "novelty" aerosols (artificial snow, "silly string", etc.). Such products are not produced in Germany, however. Use of novelty sprays with HFC-134a began in 1995, while use of sprays with HFC-152a began in 2000. The relevant emissions have been decreasing sharply since 2003. That trend is the result of a EU ban, in force as of 4 July 2009, on sale of novelty aerosols filled with hydrofluorocarbons (HFCs). Producers were quick to respond by choosing other propellants for their products.

4.7.4.2.2 Methodological issues (2.F.4.b)

Imports and exports are roughly in balance, and thus the domestic market can be considered equivalent to consumption for domestic filling. Domestic consumption refers to spray cans filled in Germany, regardless of where the cans are ultimately used.

Emission factors

In keeping with IPCC specifications (IPCC-GL, 1996b, 2.61), a 100 % emissions level for use ($EF_{Use} = 1$) is assumed; this is appropriate and justified. Of the numbers of spray cans sold in Germany, it is assumed, in keeping with the pertinent assumption in IPCC-GPG (2000), that half of the cans are used in the same year they are purchased and the other half are used in the following year.

The $EF_{Production}$ for general-purpose aerosols is based on estimates of experts.

Activity data

The data for the period prior to 1995 are based on estimates of experts. In keeping with a bottom-up approach, all quantity data as of 1995 are provided directly by producers, fillers and operators, as well as by relevant industry associations. In the case of general-purpose aerosols, filling emissions (= production emissions) are also taken into account. Estimates are based on EU-wide data.

4.7.4.3 Uncertainties and time-series consistency (2.F.4 all)

The uncertainties for the "aerosols" sub- source category have been systematically quantified.

In the case of metered dose inhalers, the surcharge factor for hospitals and doctors' samples can vary, by ± 3 %, from the above-cited 13%.

In comparison to the emissions data for metered dose inhalers, the data for other aerosols are considered to be not as good, since the large number of products involved makes it difficult to obtain an overview of the market. Large quantities of imports, especially in the area of "novelties", also complicate the situation. The uncertainties are thus considerably higher (more than 20 %).

Since the shift from CFCs to chlorine-free propellants had already been completed by the beginning of the 1990s, the time series has been largely unchanged since 1995.

4.7.4.3.1 Source-specific recalculations (2.F.4 all)

A comparison of data with survey data of the *Federal Statistical Office* made it necessary to recalculate the data for production of metered dose inhalers for 2008. The activity data for production in 2008 had to be corrected from 300 t of HFC-134a to 317 t of HFC-134a. As a result, the filling emissions increased from 3 t to 3.17 t of HFC-134a.

4.7.4.3.2 Source-specific planned improvements (2.F.4 all)

No improvements are planned at present.

4.7.5 Solvents (2.F.5)

4.7.5.1 Source category description (2.F.5)

Use of HFCs as solvents was banned in Germany up until the year 2001 (2nd Ordinance on the Implementation of the Federal Immission Control Act – 2. BImSchV) and remains heavily restricted to this day. Individual applications must be submitted for each form of use, and such applications are approved only in special cases.

4.7.5.2 Methodological issues (2.F.5)

Emissions are calculated in keeping with Tier 2 as described in IPCC-GPG 2000 (Equation 3.36).

Emission factors

No emission factor for production can be defined. Emissions in use are assumed to be completed within 2 years.

Activity data

The emissions data are based on sales data of the authorised vendor, and they apply solely to HFC-4310mee. Since the data are confidential, they are reported, under 2.G, in aggregation with data from production of halocarbons and SF₆ (2.E) and from metal production (2.C.5).

4.7.5.3 Uncertainties and time-series consistency (2.F.5)

All of the uncertainties for the sub- source category *solvents* have been identified.

4.7.5.4 Source-specific recalculations (2.F.5)

No recalculations are required.

4.7.5.5 Source-specific planned improvements (2.F.5)

No improvements are planned at present.

4.7.6 Semiconductor manufacturing (2.F.6)

4.7.6.1 Source category description (2.F.6)

The semiconductor industry currently emits PFCs (CF₄, C₂F₆, C₃F₈, c-C₄F₈), HFCs (CHF₃), nitrogen trifluoride (NF₃) and SF₆ from production processes. These gases are used for etching structures on thin layers and for cleaning reaction chambers following chemical vapour deposition (CVD). In the production process, some of the PFCs fed into plasma chambers are converted partly into CF₄.

The semiconductor industry's emissions depend partly on the degree to which the industry uses waste-gas-scrubbing equipment. They also depend directly on semiconductor-

production levels (in the present case, annual levels). As a result of these dependencies, emissions tend to fluctuate rather strongly from year to year.

4.7.6.2 Methodological issues (2.F.6)

The emissions cannot be determined solely on the basis of input quantities (sales by gas vendors), because the difference between consumption and emissions depends on a number of factors, including only-partial chemical transformation in plasma reactors and the effects of downstream waste-gas-scrubbing systems.

Emission factors

During the etching process, only about 15 % of the added CF_4 reacts chemically. The emission factor, an inverse reaction quota, thus amounts to 85 % of the CF_4 consumption.

Activity data

Reliable emissions data are available for 1990 and 1995. Linear interpolation was carried out for the years 1991 to 1994.

Until the 2000 report year, emissions data were based on surveys carried out by the EECA-ESIA (European Electronic Component Manufacturers Association – European Semiconductor Industry Association). National manufacturers were queried regarding production capacities, amounts of substances used and waste-gas treatment equipment.

As the result of a voluntary commitment by the semiconductor industry, emissions figures are available for this sub- source category, for all individual substances, from the year 2001 onwards. In keeping with a standardised calculation formula (Tier 2c approach), the emissions data are calculated for each production site, from annual consumption, aggregated and then reported by the German Electrical and Electronic Manufacturers Association (Zentralverband Elektrotechnik- und Elektroindustrie eV. - ZVEI, electronic components and systems) to the Federal Environment Agency.

4.7.6.3 Source-specific recalculations (2.F.6)

No recalculations have been carried out.

4.7.6.4 Source-specific planned improvements (2.F.6)

No improvements are planned at present.

4.7.7 Electrical equipments (2.F.7)

This source category consists primarily of use of electrical equipments (2.F.7.a), which is further sub-divided into high-voltage (HS – Hochspannungs-), medium-voltage (MS – Mittelspannungs-) and other electrical equipments. The area of particle accelerators is reported under 2.F.7.b.

4.7.7.1 Use of electrical equipments (2.F.7.a)

4.7.7.1.1 Source category description (2.F.7.a)

In electricity transmission and distribution, SF_6 is used primarily in switchgear and controlgear and equipment in high-voltage (52-380 kV) and, increasingly, in medium-voltage

(10-52 kV) networks. It serves as an arc-extinguishing and insulation medium (in the latter function, in place of air). In addition, it is used in production of components installed in gas-insulated indoor switchgear and controlgear (instrument transformers, bushings) or supplied directly to operators (high-voltage instrument transformers for outdoor installations).

As a result of first-time inclusion, in the 2002 report year, of additional SF₆ applications, the time series shows a marked jump in emissions in 2002. In report year 2005, new companies were included in reporting, especially in the new category "Other electrical equipments". For reasons having to do with the economy as a whole, more systems were sold in 2005 and 2006. Nonetheless, absolute emissions are falling overall, due to considerable reductions in the area of "other" equipments and as a result of again-lower emissions rates in switchgear and controlgear. In 1996, industry, represented by producers' and operators' associations and the SF₆ producer, committed itself to reducing emissions in life cycles of switchgear and controlgear and to provide annual progress reports. In 2005, this voluntary commitment was extended, in co-operation with the Federal Environment Agency and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), to include additional energy-transmission and energy-distribution installations above the 1 kV level. In addition, specific reduction targets were added to the commitment. The scope of voluntary reporting was enlarged and refined accordingly. In 2006, manufacturers and the gas producer made further investments in reduction measures. Substitutes for SF₆ foams were introduced in some sub-areas of bushings. This brought about further reductions in specific emissions rates and absolute emissions, even though production continued to increase.

4.7.7.1.2 *Methodological issues (2.F.7.a)*

The emissions figures are based largely on a mass balance. Increasingly, they are also being combined with emission factors for sub-areas in which the technical measurement limits for mass-balancing have been reached or in which mass-balancing would necessitate unreasonably high costs.

The methods used are based on the new "2006 IPCC Guidelines for National Greenhouse Gas Inventories; Volume 3", Chapter 8. For further information, the reader is referred to "Tier 3, Hybrid Life-Cycle Approach" in sub-chapter 8.2.

Usage emissions

Ongoing emissions from products in service include the amount of SF₆ in service, as accumulated since 1970 via annual additions of switchgear and controlgear; they are given as the average for year n.

The final amount of SF₆ in all electrical equipments for a given year n changes annually by the balance of new additions and removals. Some removals (high voltage) have been registered since 1997; large-scale removals of first-generation high-voltage switchgear and controlgear and equipment cannot be expected until after 2010, in light of the products' estimated service lifetime of at least 40 years.

Three special aspects must be taken into account in reporting relative to switchgear and controlgear:

- Calculation of the final stocks for a given year n is based on the final stocks for the previous year ($n-1$); this does not extend back to the first year of service, however. Such backward extension, an otherwise customary procedure, is not used for switchgear and controlgear, because operators/manufacturers estimated the SF_6 stocks in service for 1995. Their estimate was broken down into high-voltage and medium-voltage categories (770 t and 157.6 t, respectively).
- In the area of high-voltage switchgear and controlgear, stocks and emissions are determined via direct surveys of the some 100 operators. In such surveys, the operators are asked to provide data on their current stocks of SF_6 in electrical equipments (gas-insulated HV switchgear (GIS), circuit breakers, outdoor instrument transformers). Emission factors determined on the basis of reference systems are then applied to such stocks data.
- The group of operators of medium-voltage switchgear is very numerous and highly diverse. It is thus not feasible to conduct direct surveys. Manufacturers of medium-voltage switchgear have themselves taken responsibility for updating their domestic stock data on the basis of their sales data. The emissions can be determined in that the systems are practically maintenance-free and, by definition (IEC 62271-1), require no refilling throughout their entire lifetimes. The emissions are minimal (usually, they occur only as a result of external influences), and they can be accounted for via a lump-sum emission factor (resulting from survey of experts): the emissions rate has been set at a constant 0.1 % since 1998, since virtually all of the systems added to domestic stocks since the mid-1990s are systems that are "sealed for life" (hermetically sealed pressurised systems pursuant to IEC). In their voluntary commitment of 2005, the operators also promised to use only such systems. As a result, the impact of the few older systems that have emissions rates greater than 0.1 % has diminished. Stocks are calculated, in each case, by adding new additions to the previous year's stock level and deducting decommissioned units. To date, for reasons of practicality, the resulting calculatory, marginal, emissions-based reductions of stocks have not been taken into account.

Disposal emissions

Because switchgear and controlgear have long service lifetimes (40 years), and because the first use of SF_6 dates from the late 1960s, disposal emissions are just now beginning to occur, on a small scale. The amounts of SF_6 (AD), from old switchgear and controlgear (high-voltage and medium-voltage), that now need to be disposed of thus simply have been roughly estimated to date (at a constant 3 t/a). As of the 2005 report year, amounts for disposal from systems removal are being determined precisely for the first time, by the relevant associations. This also applies to emissions from disposal, which prior to 2005 were estimated at 0.06 t.

Activity data

In the framework of manufacturers' voluntary commitment, annual consumption by manufacturers of electrical equipments, and stocks of medium-voltage switchgear and controlgear, are reported to the Federal Environment Agency by the German Electrical and Electronic Manufacturers' Association (ZVEI), while stocks of high-voltage switchgear and controlgear, outdoor-mounted instrument transformers, gas-insulated lines and transformers are reported by the Association of German network operators (VDN) and, since 2004, by the

Association of the Energy and Power Generation Industry (VIK). Participants in the voluntary commitment jointly determine quantities of decommissioned units.

Table 109 shows the 2009 inventory data, broken down by sub- source categories, along with pertinent explanations. The sum total for electrical equipments for energy transmission and distribution agrees with the data in Table 2 (II)F, Sheet 2, source category 2.F.8 in the CRF.

Table 109: 2009 inventory data for source category 2.F.7, including relevant sub- source categories

Source category 2.F.7 - Electrical equipments for energy transmission and distribution, with sub- source categories - 2009 inventory	Activity data			Emissions	
	Annual consumption, production	Stocks	Decommissioned	Production	Operation
	(Tonnes of SF ₆)				
Electrical equipments for energy transmission and distribution 2.F.8 (total), including:	912.9	1955	5.8	13.7	7.4
MV switchgear and controlgear (in hermetically sealed pressurised systems)*	153.0	799.7	0.17	1.0	0.8
HV S switchgear and controlgear (in hermetically sealed pressurised systems)**	681.0	978.2	5.65	4.7	6.1
Other electrical equipments ***	78.9	177.3	IE	8.0	0.5

IE= included in "HV switchgear and controlgear..."; marginal

Explanatory remarks:

* Hermetically sealed pressurised systems pursuant to IEC 62271-1 for the range 1kV through 52 kV; also known as "sealed for life" systems

** Sealed pressurised systems pursuant to IEC 62271-1 for the range above 52 kV

*** Gas-insulated transformers: marginal residual stocks in the network; (no production emissions) + high-voltage instrument transformers for outdoor installation (all emissions categories) + gas-insulated lines (GIL) (all emissions categories) + high-voltage bushings (only production emissions) + medium-voltage cast-resin instrument transformers (only production emissions) + testing of medium-voltage components (only production emissions) + 1000V capacitors (only production emissions)

4.7.7.1.3 Uncertainties and time-series consistency (2.F.7.a)

Since there are only about ten different manufacturers of electrical equipments (including bushings and instrument transformers), the consumption data, and the new-additions and decommissioned-units figures, are highly reliable. This holds all the more in that such data and figures are based on internal accounting, and that fill amounts are determined with great precision and then noted on devices' name plates. The pertinent uncertainty is in the area of ± 5 %.

Determination of emissions is more difficult, since the plants typically concerned have several different emissions sources, each quite small. Gas losses occur in filling of devices, in testing, in opening of products that fail to pass quality inspections, in product development, etc.. On the other hand, all domestic plants proceed in accordance with a standardised questionnaire that lists all possible emissions sources and that is checked for correctness during surveys. For this reason, and because there are few manufacturers (see above), the precision of data collection ultimately depends on the precision of the relevant measurements. The resulting figures lie within ± 10 % of estimates.

Emissions from operation in the high-voltage sector are determined by operators, via annual refilling, which is carried out by operators' own personnel or by manufacturers' service networks. (Refilling is carried out when the fill level drops below 90 % of the desired fill level;

normally, devices are equipped to show any need for refilling.) This method can be considered very reliable, i.e. the deviations from the actual value are about ± 5 %. All surveys to date have produced similar results for emissions rates; all results are within a range from 0.75 to 0.88 %. The one-time emissions-rate peak for high-voltage switchgear and controlgear that occurred in 2004 is the result of special events. In the main, it was due to simultaneous refilling of old, older-model systems that were less well-sealed.

In the year 2000, an unusual development occurred in high-voltage in-service stocks and, thus, in emissions, both of which had been increasing since 1995: a decrease with respect to the previous year. For in-service stocks, the decrease amounted to over 25 t, while for emissions it amounted to 0.85 t. That decrease, which was due to trends in gas-insulated HV switchgear (GIS) (600 to 567 t), cannot be explained as the result of decommissioning removals, since the role of such removals is still insignificant. According to the VDN, which carries out the surveys, the underlying problem is both statistical and organisational in nature. At the end of the 1990s, electricity-market liberalisation led to profound operator regrouping (through mergers and changes in ownership of various parts of companies). Along with those changes, personnel assignments relative to electrical equipments in service were repeatedly changed. As a result, double-counting cannot be ruled out in 1999, nor can the possibility be ruled out that some systems were not included in 2000. Apart from these aspects, the uncertainty today – now that a stable state has been attained – can be assumed to lie in the range of ± 5 % for high-voltage stocks.

The emissions rate of 0.1 % in the medium-voltage sector may be considered acceptable for stocks in recent years.

4.7.7.1.4 *Source-specific recalculations (2.F.7.a)*

No recalculations are required.

4.7.7.1.5 *Source-specific planned improvements (2.F.7a)*

No improvements are planned at present.

4.7.7.2 *Use in particle accelerators (2.F.7.b)*

4.7.7.2.1 *Source category description (2.F.7b)*

SF₆ is used in elementary particle accelerators as an insulating gas. High-voltage accelerator systems (0.3 to more than 23 MV) are used by university institutes, research groups and industry. In industry, low-voltage devices with less than 0.3 MV are also used. Yet another relevant category consists of radiation-therapy devices in medical facilities.

4.7.7.2.2 *Methodological issues (2.F.7.b)*

In early 2004, Öko-Recherche, working under commission to the Federal Environment Agency, carried out a complete survey of particle accelerators within the country, with the aim of updating pertinent data, some of which date from 1996. In the process, both users and producers of the devices/systems were queried. The questions posed had to do with the quantities of SF₆ in their devices and with refills of SF₆ carried out during the last seven years.

The CSE assumes responsibility for structuring the survey. For all five relevant categories, it contains annual data on SF₆ stocks and on replacements to compensate for emissions. The emissions in question include both ongoing emissions and minor filling and disposal losses.

4.7.7.2.3 *Uncertainties and time-series consistency (2.F.7.b)*

The uncertainties for this source category have been systematically quantified.

4.7.7.2.4 *Source-specific recalculations (2.F.7b)*

No recalculations are required.

4.7.7.2.5 *Source-specific planned improvements (2.F.7b)*

No improvements are planned at present.

4.7.8 *Other (2.F.8)*

This source category comprises the uses *Sound-proof glazing* (2.F.8.a), *Automobile tyres* (2.F.8.b), *Sport shoes* (2.F.8.c), *Trace gas* (2.F.8.d), *AWACS maintenance* (2.F.8.e), *Welding* (2.F.8.f), *Optical glass fibres* (2.F.8.g) and *Photovoltaics* (2.F.8.h).

4.7.8.1 *Sound-proof glazing (2.F.8.a)*

4.7.8.1.1 *Source category description (2.F.8.a)*

Since 1975, SF₆ has been used to enhance the soundproofing properties of multi-pane windows. In such use, the gas is inserted into the spaces between the panes. The disadvantages of such use are that it reduces windows' thermal-insulation performance and that SF₆ is a powerfully acting greenhouse gas. The higher priority given to thermal insulation – e.g. by the Thermal Insulation Ordinance (Wärmeschutzverordnung) – along with improved SF₆-less window technologies, have led to a reduction in use of SF₆ in this application since the mid-1990s.

In Germany, sound-proof windows have been produced by numerous companies and filled with gas. Exports of assembled windows play no significant role.

Since 4 July 2007, a ban has been in force in the EU on sale of windows, for residential uses, that are filled with fluorinated greenhouse gases. As of 4 July 2008, that ban also applies to other windows. Current and future emissions in this source category thus come primarily from open waste management of old windows, which is assumed to occur an average of 25 years after the windows were filled. For this reason, total emissions are expected to continue growing until the year 2020.

4.7.8.1.2 *Methodological issues (2.F.8.a)*

Emissions occur during filling of spaces between panes, as a result of overfilling (production emissions), during use (use emissions) and in disposal (disposal emissions). Emissions are calculated in keeping with with equations 3.24 – 3.26 of IPCC-GPG (2000) on the basis of new domestic consumption, average annual stocks and remaining stocks 25 years ago.

The time series for sound-proof glazing begin in 1975, since the filling quantities of the year 1975 are of relevance for emissions from stocks in 1995. These data, which were

reconstructed with the help of industry experts in 1996, were published in 2004 for the first time.

Emission factors

According to expert-level information from manufacturers of windowpanes and gas-filling equipment, provided to industry experts and to a scientific institute, one-third of the SF₆ used in the process of pumping SF₆ into spaces between windowpanes escapes. The EF_{Production} is thus 33 %, with respect to new annual consumption.

This emission factor is obtained in the following manner: In use of both manual filling devices and automatic gas-filling presses, gas-swirling in the space between the panes cannot be avoided. As a result, the escaping gas consists not only of the air originally between the panes, it also includes an air-SF₆ mixture. More and more mixed gases escape as the filling process progresses. The gas loss, the "overfill", ranges from 20 to 60 % of the amount filled. The smaller the window concerned, the greater the overfill's relative importance. On average, i.e. throughout the entire spectrum of filled windows, of all shapes and sizes, the overfill level amounts to 50 % of the amount actually contained between the panes. This corresponds to one-third (33 %) of the relevant consumed amounts. This emission factor continues to be used, since neither filling technologies nor the range of window geometries have changed.

A DIN standard (DIN EN 1279-3, DIN 2003) specifies an upper limit of 10 per mil for annual losses of filled gas from panes' peripheral seals. This value also takes account of gas losses resulting from glass breakage in transport, installation and use, as well as from age-related increasing leakage from peripheral seals. The result is an emission factor E_{Use} of 1 % with respect to the average SF₆ stocks that have accumulated since 1975 and that are in place in year n.

Finally, disposal losses are incurred at the end of windows' service lifetimes (utilisation periods), or an average of 25 years after the windows were filled. For this reason, emissions from disposal do not have to be taken into account until the year 2000.

Since each year a window loses 1 % of its gas, with respect to the previous year's value, only part of a window's original quantity of gas is emitted when the window undergoes disposal. Since no gas collection upon disposal takes place, however, the emissions level is 100% (EF_{disposal} = 1).

Activity data

The new annual consumption is determined via top-down survey (domestic sales by the gas industry). Practical reasons – the large number of manufacturers involved (nearly 400) – preclude any double-checking via bottom-up survey (manufacturers' purchase data). From 2006 through 2009, data for annual new consumption were checked against the *Federal Statistical Office's* pertinent annual surveys.

4.7.8.2 Automobile tyres (2.F.8.b)

4.7.8.2.1 Source category description (2.F.8.b)

Beginning in 1984, automobile tyres were filled with SF₆ for reasons of image (the resulting improved pressure constancy is not relevant in practice). The largest annual consumption occurred in 1995, when over 500 of the some 3,500 tyre-sales outlets in Germany had the

option of filling tyres with SF₆ gas. Because SF₆ is a powerfully acting greenhouse gas, many tyre dealers began filling tyres with nitrogen instead. This practice led to a considerable reduction in use of SF₆. Since 4 July 2007, a ban has been in force in the EU on sale of new automobile tyres filled with fluorinated greenhouse gases. The bulk of today's emissions originates from gas in older filled tyres.

4.7.8.2.2 Methodological issues (2.F.8.b)

For the sake of simplicity, gas emissions during tyres' service lifetimes are not taken into account; as a result, emissions occur only when tyres are dismantled. Given an intended service lifetime of about 3 years, and the fact that there is no foreign trade with filled types, emissions follow domestic consumption for filling with a three-year time lag (ÖKO-RECHERCHE, 1996). The emissions are calculated using equation 3.23 of IPCC-GPG (2000).

Emission factors

The very small losses incurred in filling of tyres are not taken into account. Since SF₆ escapes completely when tyres are dismantled, $EF_{\text{Disposal}} = 1$.

Activity data

Annual sales are determined via surveys, carried out by the Federal Statistical Office, of gas suppliers, regarding their domestic sales to tyre dealers and automobile service centres.

4.7.8.3 Sport shoes (2.F.8.c)

4.7.8.3.1 Source category description (2.F.8.c)

In the past, SF₆ has been inserted into the soles of sport shoes in order to enhance cushioning. 2003 was the last year in which this practice was followed throughout Europe. Beginning in 2004, PFC-218 (C₃F₈) was used. Use of that substance was discontinued in 2006, and now nitrogen is used in most cases. Sale of footwear produced with fluorinated greenhouse gases has been prohibited in the EU since 4 July 2006. Current emissions occur only in disposal of sport shoes.

4.7.8.3.2 Methodological issues (2.F.8.c)

The emissions are calculated using equation 3.23 of IPCC-GPG (2000).

Production emissions occur only in foreign countries. Current emissions from stocks are not determined.

In keeping with a commitment to maintain confidentiality, data relative to sport-shoe soles are reported under CRF 2.G, together with data for aircraft radar, welding and use of SF₆ in aluminium foundries.

Emission factors

Manufacturers do not report production emissions.

It is assumed that no emissions occur during use.

In disposal, emissions may be equated with input quantities ($EF_{\text{Disposal}} = 1$). In addition, in a procedure similar to the IPCC method for automobile tyres, a time lag of three years is assumed.

Activity data

The filled quantities are based on manufacturers' European-wide sales figures. These figures are broken down, on the basis of Germany's population, to obtain figures for Germany. While such data have been available to the Federal Environment Agency since the 2001 report year, they are published only in aggregate form, for reasons of confidentiality.

4.7.8.4 Trace gas (2.F.8.d)

4.7.8.4.1 Source category description (2.F.8.d)

SF₆, as a stable and readily detectable trace gas, even at extremely low concentrations, is used by research institutions to investigate a) ground-level and atmospheric airflows and gas dispersions and b) water currents.

As of report year 2007, use of SF₆ as a trace gas decreased considerably with respect to earlier years.

4.7.8.4.2 Methodological issues (2.F.8.d)

In contrast to the procedure followed for equation 3.22 in IPCC GPG (2000), the quantities used are determined via experts' assessments, and not via gas-sellers' sales figures. New consumption for this open use is listed in CRF Table 2(II).Fs2 under "amount of fluid filled in new manufactured products", because this description covers the manner in which the gas is actually used in this application.

Emission factors

An "open use" is assumed, i.e. annual new inputs are completely emitted in the same year and are treated as consumption for production ($EF_{\text{Production}} = 1$). No recovery takes place.

Activity data

In 1996, total domestic use was estimated by experts of all relevant research institutions. Since then, use levels have been estimated by one expert at three-year intervals. These assessments indicate that the quantities used vary only slightly.

4.7.8.5 AWACS (Airborne Warning and Control System) maintenance (2.F.8.e)

4.7.8.5.1 Source category description (2.F.8.e)

SF₆ is used as an insulating medium for radar in Boeing E-3A (NAEWF; formerly, AWACS) aircraft, which are large military surveillance aircraft. It is used to prevent electrical arcing, towards the antenna, in waveguides with high voltages in excess of 135 kV. Ongoing emissions are relatively high, since SF₆ is released to equalize pressure as aircraft climb.

4.7.8.5.2 *Methodological issues (2.F.8.e)*

Activity data

The emissions figures are based on reported purchased quantities for filling and refilling of NATO's NAEWF fleet. Reported sales figures are double-checked against gas-sellers' statistics. The emissions data for report years until 2001 are based on estimates that are themselves based on a survey from the year 1996. For this reason, the emissions data for the years 1997 to 2001 are imprecise. For report year 2002, a new survey of consumed quantities was carried out. This showed a significant increase over relevant quantities in report year 2001.

Experts consider the annual SF₆ requirements for the NAEWF fleet to be constant.

Data on AWACS maintenance are reported under CRF 2.G, together with data on sport-shoe soles, welding applications and use of SF₆ in aluminium foundries, since the data are confidential.

4.7.8.6 *Welding (2.F.8.f)*

4.7.8.6.1 *Source category description (2.F.8.f)*

According to gas suppliers, use of SF₆ in welding began in 2001. SF₆ is used as a protective gas in welding of metal. Since there is only one user in Germany, the pertinent data are subject to confidentiality protection.

4.7.8.6.2 *Methodological issues (2.F.8.f)*

Because they are confidential, data on consumption and emissions in connection with welding are reported under CRF 2.G, together with data for applications in sport shoes, for AWACS maintenance and for use of SF₆ in aluminium foundries.

Emission factors

No reliable data are available on SF₆ decomposition during use. Experts presume that the entire relevant input SF₆ quantities are emitted completely into the atmosphere during use. For this reason, consumption and emissions are considered equal for welding applications. The emission factor for welding is specified as EF_{Use} = 1.

Activity data

The annual amounts consumed are determined via enquiry of the company that uses SF₆ for welding purposes.

4.7.8.7 *Optical glass fibre (2.F.8.g)*

4.7.8.7.1 *Source category description (2.F.8.g)*

Use of SF₆ in production of optical glass fibre began in 2002. In production of optical glass fibre, SF₆ is used for fluorine doping. Numerous production operations are in place in Germany.

4.7.8.7.2 *Methodological issues (2.F.8.g)*

Emissions occur in production of optical glass fibre cable.

Emission factors

The 2006 IPCC Guidelines⁴⁹ contain no information on use of SF₆ in production of optical glass fibre. According to experts, 70 % of the input SF₆ quantities escape. For this reason, an emission factor of EF_{Production} = 0.7 is applied.

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales.

4.7.8.8 Photovoltaics (2.F.8.h)

4.7.8.8.1 Source category description (2.F.8.h)

In wafer production in Germany, SF₆ and other fluorine compounds are used for structure etching and for cleaning of reaction chambers during production processes. Since the purity of the process gas is lower than that of the gas used in the similar production process in the semiconductor industry, use for *photovoltaics* is reported separately. In Germany, use of SF₆ in solar technology began in 2002.

The time series shows a continuous emissions increase between 2002 and 2006; this is due to increases in production. A large jump occurred in 2007 and 2008, when quantities of produced wafers and, thus, the quantities of SF₆ used, increased sharply. In 2009, the opposite effect occurred.

Since 2008, NF₃ has substituted for SF₆ in all new production lines for production of Si thin-film cells.

In addition, in 2002/2003 the hydrocarbon CF₄ was introduced for "edge insulation" of crystalline solar cells. The procedure using that substance was soon supplanted by a different procedure that is easier to handle, however. By the end of 2009, consumption of CF₄, which in 2004 reached a maximum of nearly 5 t, decreased to less than 1 t. Such consumption is expected to disappear altogether by 2013 at the latest. That consumption is being reported for the first time this year.

4.7.8.8.2 Methodological issues (2.F.8.h)

Like emissions in the semiconductor industry, emissions in photovoltaics occur during production. The relevant production emissions cannot be determined solely on the basis of the quantities used (sales by the gas trade). The differences between consumption and emissions result from a) the fact that chemical conversion in plasma reactors is only partial and b) the effects of downstream waste-gas-scrubbing systems.

Emission factors

In 2009, only one producer in Germany did not have a waste-gas-scrubbing system. For this reason, the IPCC emission factor of 40% is used only for the first year of pertinent use, 2003. Thereafter, the emission factor decreases, as the percentage of wafer production connected to downstream waste-gas-scrubbing systems increases. In 2009, it was just less than 6%.

⁴⁹ IPCC GL 2006, Vol. 6, chapter 6: Electronics Industry

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales. In addition, the data were checked in a separate study entitled "SF₆ and NF₃ in the German photovoltaic industry" ("SF₆ und NF₃ in der deutschen Photovoltaik-Industrie") (ÖKO-RECHERCHE, 2009: FKZ 360 16 027).

4.7.8.9 Uncertainties and time-series consistency (2.F.8 all)

In the case of sound-proof glazing, since 2006 data from the top-down survey of annual new consumption, carried out on the basis of commercial sales data, have been compared with data from the *Federal Statistical Office's* pertinent annual surveys. This procedure, which may be considered reliable and complete, has increased data reliability. Due to the wide range of influencing factors, the EF_{Production} cannot be measured reliably. Estimates resulting from a survey of ten industry experts, conducted in 1996 and 1999 (the experts represented window manufacturers, suppliers of filling devices and one scientific institute) indicate, virtually conclusively, that the mean filling loss ranges between 30 % and 40 %. A 1 % rate is considered realistic for ongoing gas losses.

With regard to sport shoes, in spite of the good quality of the data for the EU, the filled-quantities breakdown, by Member States, is subject to considerable uncertainties.

4.7.8.10 Source-specific recalculations (2.F.8 all)

Recalculations in source category 2.F.8.h "Photovoltaics" were carried out for the period as of report year 2002. Those recalculations are based on the study mentioned above in the present chapter, a study for which direct discussions with producers were conducted. Data for the substances CF₄ (for edge insulation) and NF₃ are being reported for the first time. The changes in the relevant activity data, emissions and emission factors for production with SF₆ are listed in Table 110.

Further recalculations were carried out for source category 2.F.8.a "Sound-proof glazing". In that area, an expert review of the relevant model led to specifics that, in turn, led to slightly changed activity data and emissions for use as of report year 2001 and for disposal as of report year 2000. All of the changes are shown in Table 111.

Table 110: Overview of the recalculation-related changes in activity data (AD), emissions (EM) and emission factors (EF) for SF₆, NF₃ and CF₄ in production of photovoltaic cells in source category 2.F.8.h.

2.F.8.h Production of photovoltaic cells	Units	2002	2003	2004	2005	2006	2007	2008
AD production, SF₆								
Resubmission 2010	t	0.300	1.200	1.200	2.000	5.720		40.040
Submission 2011	t	0	1.750	2.520	2.490	6.450		58.082
Difference	t	- 0.300	+ 0.550	+ 0.320	+ 0.490	+ 0.730		+ 18.042
EM production, SF₆								
Resubmission 2010	t	0.150	0.600	0.600	1.000	2.960	12.469	20.020
Submission 2011	t	0	0.700	0.839	0.857	0.961	1.721	3.253
Difference	t	- 0.150	+ 0.100	+ 0.239	- 0.143	- 1.899	- 10.748	- 16.767
EF production, SF₆								
Resubmission 2010	[1]	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Submission 2011	[1]	0.400	0.400	0.333	0.344	0.149	0.069	0.056
Difference	%	- 20	- 20	- 33.4	- 31.2	- 70.2	- 86.2	- 88.8
AD production, NF₃								
Resubmission 2010	t					0	0	0
Submission 2011	t					2.74	5.80	30.20
Difference	t					+ 2.74	+ 5.80	+ 30.20
EM production, NF₃								
Resubmission 2010	t					0	0	0
Submission 2011	t					0.04	0.09	0.45
Difference	t					+ 0.04	+ 0.09	+ 0.45
EF production, NF₃								
Resubmission 2010	[1]					0	0	0
Submission 2011	[1]					0.015	0.015	0.015
Difference	%					100	100	100
AD production, CF₄								
Resubmission 2010	t	0	0	0	0	0	0	0
Submission 2011	t	3.769	4.400	4.876	4.414	3.812	3.950	1.544
Difference	t	+ 3.769	+ 4.400	+ 4.876	+ 4.414	+ 3.812	+ 3.950	+ 1.544
EM production, CF₄								
Resubmission 2010	t	0	0	0	0	0	0	0
Submission 2011	t	0.264	0.308	0.341	0.309	0.267	0.277	0.108
Difference	t	+ 0.264	+ 0.308	+ 0.341	+ 0.309	+ 0.267	+ 0.277	+ 0.108
EF production, CF₄								
Resubmission 2010	[1]	0	0	0	0	0	0	0
Submission 2011	[1]	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Difference	%	+ 100	+ 100	+ 100	+ 100	+ 100	+ 100	+ 100

Table 111: Overview of the recalculation-related changes in the activity data (AD) and emissions (EM) for SF₆ in source category 2.F.8.a – sound-proof glazing.

2.F.8.a Sound-proof glazing	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008
AD use										
Resubmission 2010	t		2063.51	2077.83	2072.72	2057.00	2030.95	1993.50	1947.17	1892.72
Submission 2011	t		2059.27	2066.35	2052.25	2027.20	1991.50	1944.07	1887.43	1822.34
Difference	t		- 4.24	- 11.48	- 20.48	- 29.80	- 39.45	- 49.43	- 59.74	- 70.38
EM use										
Resubmission 2010	t		20.64	20.78	20.73	20.57	20.31	19.93	19.47	18.93
Submission 2011	t		20.59	20.66	20.52	20.27	19.91	19.44	18.87	18.22
Difference	t		- 0.04	- 0.11	- 0.20	- 0.30	- 0.39	- 0.49	- 0.60	- 0.70
AD disposal										
Resubmission 2010	t	2.74	5.60	11.41	17.53	23.86	30.43	37.24	44.30	51.61
Submission 2011	t	5.60	11.41	17.53	23.86	30.43	37.24	44.30	51.61	59.15
Difference	t	+ 2.86	+ 5.81	+ 6.12	+ 6.33	+ 6.57	+ 6.82	+ 7.06	+ 7.30	+ 7.55
EM disposal										
Resubmission 2010	t	2.74	5.60	11.41	17.53	23.86	30.43	37.24	44.30	51.61
Submission 2011	t	5.60	11.41	17.53	23.86	30.43	37.24	44.30	51.61	59.15
Difference	t	+ 2.86	+ 5.81	+ 6.12	+ 6.33	+ 6.57	+ 6.82	+ 7.06	+ 7.30	+ 7.55

4.7.8.11 Source-specific planned improvements (2.F.8 all)

No improvements are planned at present.

4.7.9 Source-specific quality assurance / control and verification (2.F all)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data for the 2003 report year, like the data for most of the previous years, were collected by an external expert working in the framework of a research project under commission to the Federal Environment Agency.

For the most part, quality assurance was carried out by an external expert. In addition, the data are checked by the relevant Federal Environment Agency specialist upon receipt.

The collected data on the size of source-category-specific HFC stocks, on composition of those stocks with regard to various HFC refrigerants, on EF, etc. are subject to continual quality assurance / control and verification, although this process has not yet been standardised. On a regular basis, various sources (environmental statistics⁵⁰, production and sales figures⁵¹, etc.) are consulted, and experts (users, refrigerant manufacturers, suppliers, etc.) are consulted to determine the sources' reliability.

The data for electrical equipments and semiconductor production have undergone an internal association process of quality assurance / control and verification.

The whole sector on F-gas emissions was evaluated in a voluntary trilateral review in February 2011. Experts from the United Kingdom, Germany, and Austria reviewed the chapters of the respective countries. Ideas resulting from this informal and voluntary review will be used to further improve the model on which calculations are based wherever possible.

⁵⁰ Surveys pursuant to Art. 11 of the Environmental Statistics Act (UstatG).

⁵¹ Surveys pursuant to the Foreign Trade Statistics Act (AHStatGes) and production statistics.

4.8 Other areas (2.G.)

Emissions of SF₆ from applications in *sport shoes* (2.F.8.c Other – sport shoes), uses in connection with *AWACS maintenance* (2.F.8.e Other – AWACS maintenance), use in connection with *welding* (2.F.8.f Other – welding) and from use in *aluminium production* (2.C.4a Metal production: SF₆ in secondary aluminium production) are reported under 2.G, for reasons of confidentiality.

Emissions of HFCs, from uses as solvents (2.F.5 Solvents) and uses in metal production (2.C.5 Metal production: Other) are reported under 2.G, for reasons of confidentiality.

PFC emissions from PFC production (2.E Production of halocarbons and SF₆), from use in sport shoes (2.F.8.c Other – sport shoes) and from industrial refrigeration (2.F.1d Industrial refrigeration) are reported under 2.G, for reasons of confidentiality.

No other sources of relevant greenhouse-gas emissions are known.

5 SOLVENTS AND OTHER PRODUCT USE (CRF SECTOR 3)

5.1 Overview (CRF Sector 3)

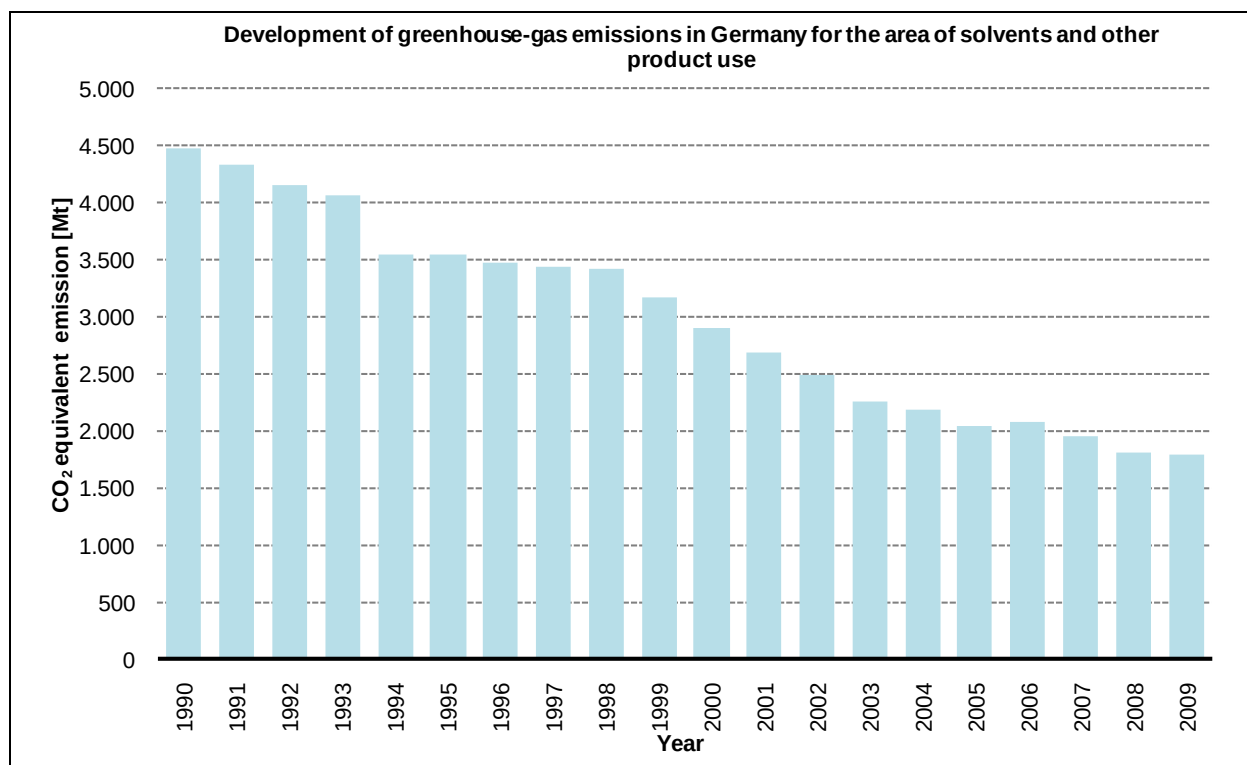


Figure 42: Overview of greenhouse-gas emissions in CRF Sector 3

This source category comprises emissions from the use of chemical products. Currently, the source category includes information on solvent emissions from applications in the industry, commercial/institutional and residential sectors, as well as detailed information about release of N₂O during its use.

Source category 3, *Solvents and other product use*, is divided into the sub- source categories *Paint application* (3.A), *Degreasing and dry cleaning* (3.B), *Chemical products, manufacture and processing* (3.C) and *Other product use* (3.D). *Other product use* (3.D) includes emissions of laughing gas (cf. Chapter 5.3), emissions from selective catalytic reduction (SCR) systems and the above-detailed other solvent uses that cannot be allocated to source categories 3A through 3C.

The N₂O emissions from source category 3.D *Other product use* are reported separately from other emissions categories in Chapter 5.3.

5.2 Solvents - NMVOC (3.A-3.C & 3.D)

5.2.1 Source category description (3.A-3.C & 3.D)

CRF 3A - 3C, 3D (NMVOC)				
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
- / -				

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	NO	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category NMVOC emissions from the area of *Solvents and other product use* (CRF 3.A-3.C and 3.D) is not a key source.

The NMVOC emissions released through use of solvents and solvent-containing products all belong to sub-categories of this source category.

The four categories 3.A - 3.D vary widely in structure. To take account of this variation, inventory data were calculated in keeping with the UNECE/EMEP sub-structures based on the CORINAIR97 (CORINAIR: COordination d' INformation Environnementale; sub-project AIR) SNAP system⁵².

Source category 3.D *Other product use* includes the following uses and activities:

- Treatment of glass and rock wool
- Printing industry (printing applications)
- Extraction of oils and fats
- Use of glues and adhesives
- Use of wood preservatives
- Undersealing and wax treatments for automobiles
- Household use of solvents (not including paints and lacquers)
- Automobile-wax stripping
- Manufacturing of pharmaceutical products
- Household use of pharmaceutical products
- Other

"NMVOC" is defined in keeping with the VOC definition found in the EC solvents directive⁵³. For purposes of the definition of solvents, the term "solvent use" is also defined in keeping with the EC solvents directive⁵⁴.

It is important to note that some volatile organic compounds are used both as solvents and as chemical reactants – for example, toluene, which is used as a solvent in lacquers and glues and as a reactant for production of toluenediisocyanate (TDI), and methyl ethyl ketone (butanone), which is used as a solvent in printing inks and as a base material for synthesis of

⁵² In the present area, this involves "SNAP Level 3" detailing.

⁵³ In this definition, volatile organic compounds (VOC) include all organic compounds that are volatile at 293.15 K, at a vapour pressure of at least 0.01 kPa or under the usual conditions for their use.

⁵⁴ In this definition, an organic solvent is a volatile organic compound that, either by itself or in combination with other raw materials, products or waste substances, and without changing chemically, either dissolves or is used as a cleanser for dissolving dirt accumulations, as a solvent, as a dispersing agent, as an agent for adjusting viscosity or surface tension, or as a softener or preservative.

methyl ethyl ketone peroxide. Consequently, VOC (either substances or fractions of substances or products) used as chemical reaction components are not included in this source category.

Delimitation of this source category as outlined above takes a highly diverse range of emissions-causing processes into account. The factors considered with regard to such processes include:

- Concentrations and volatility of VOC used.
The relevant spectrum includes use of volatile individual substances as solvents – for example, in cleansing; use of products with solvent mixtures – for example, in paints and lacquers; and applications in which only small parts of mixtures used (also) have solvent properties (as is the case, for example, in polystyrene-foam production)
- The great differences in emissions conditions.

Solvent uses can be open to the environment – as is the case in use of cosmetics – or largely closed to the environment – as in extraction of essential oils or cleaning in chemical dry-cleaning systems.

5.2.2 Methodological issues (3.A-3.C & 3.D)

NMVOC emissions are calculated via an approach oriented to product consumption. In this approach, the NMVOC input quantities allocated to these source categories, via solvents or solvent-containing products, are determined and then the relevant NMVOC emissions (for each source category) are calculated from those quantities via specific emission factors. This method is explicitly listed, under "consumption-based emissions estimating", as one of two methods that are to be used for emissions calculation for this source category.

Use of this method is possible only with valid input figures – differentiated by source categories – in the following areas:

- Quantities of VOC-containing (pre-) products and agents used in the report year,
- The VOC concentrations in these products (substances and preparations),
- The relevant application and emission conditions (or the resulting specific emission factor).

To take account of the highly diverse structures throughout the categories 3.A – 3.D, these input figures are determined on the level of 37 differentiated source categories (in a manner similar to that used for CORINAIR SNAP Level 3), and the calculated NMVOC emissions are then aggregated. The product / substance quantities used are determined at the product-group level with the help of production and foreign-trade statistics. Where possible, the so-determined domestic-consumption quantities are then further verified via cross-checking with industry statistics.

The values used for the average VOC concentrations of the input substances, and the emission factors used, are based on experts' assessments (expert opinions and industry dialog) relative to the various source categories and source-category areas. Not all of the necessary basic statistical data required for calculation of NMVOC emissions for the most current relevant year are available in final form; as a result, the data determined for the previous year are used as a basis for a forecast for the current report. The forecast for NMVOC emissions from solvent use for the relevant most current year is calculated on the basis of specific activity trends. As soon as the relevant basic statistical data are available for

the relevant most current year, in their final form, the inventory data for NMVOC emissions from solvent use are recalculated.

Since 1990, NMVOC emissions from use of solvents and solvent-containing products have decreased by about 42 %. The main emissions reductions have been achieved in the years since 1999. This successful reduction has occurred especially as a result of regulatory provisions such as the 31st Ordinance on the execution of the Federal Immissions Control Act (*Ordinance on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain facilities – 31. BImSchV*), the 2nd such ordinance (*Ordinance on the limitation of emissions of highly volatile halogenated organic compounds – 2. BImSchV*) and the TA Luft. The German "Blauer Engel" ("Blue Angel") environmental quality seal, which is used to certify a range of products, including paints, lacquers and glues with low solvent concentrations, has also played an important role in this development.

While product sales increased in some areas – even over periods of several years – thereby adding to emissions, the above-described measures offset this trend. These successes, which have occurred especially in recent years, are reflected in the updated emissions calculations – which, thanks to methods optimisation, now feature greater differentiation of VOC concentrations and emission factors.

For the 2009 report, indirect CO₂ emissions from NMVOC were calculated for the first time. The following relationship was used for pertinent conversion:

$$EM_{\text{Indirect CO}_2} = EM_{\text{NMVOC}} * \text{molar mass CO}_2 / \text{molar mass C} * 75 \%$$

Since compatibility with EU greenhouse-gas reporting is the primary methodological backdrop for conversion of NMVOC emissions into indirect CO₂ emissions, for the current report we have used the reference approach proposed in *Chapter 7 Precursors and Indirect Emissions* of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories:

$$EM_{\text{Indirect CO}_2} = EM_{\text{NMVOC}} * \text{molar mass CO}_2 / \text{molar mass C} * 60 \%$$

5.2.3 *Uncertainties and time-series consistency (3.A-3.C & 3.D)*

At the time of the report, errors had been estimated for NMVOC emissions; this was carried out using the error-propagation method and on the basis of experts' assessments for all input figures (in all 37 differentiated source categories). The main source of current uncertainties consists of inadequate precision in separation of basic statistics (production and foreign-trade statistics), with regard to categorisation in VOC-containing and VOC-free products, and with regard to use in different source categories with highly differing emissions conditions.

5.2.4 *Source-specific quality assurance / control and verification (3.A-3.C & 3.D)*

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The NMVOC-emissions data for the years 2006 through 2009 that are used in the emissions inventory were collected in the framework of a research project, and they were evaluated, by Federal Environment Agency experts, and also in the framework of that project, for methodological and material consistency, plausibility and completeness. In the course of that review, the relevant methods were optimised in co-operation with the affected industry

sectors. In comparisons made with older emissions calculations in source category 3.A "Paint application", it is especially important to review methods for, and to adjust as necessary, categorisation of products as either VOC-containing or VOC-free products. Relevant corrections have reduced total emissions in source category 3 by more than 30 Gg.

In an additional result of the research project, the survey methods were adapted to the latest changes in the underlying basic statistical systems; this adaptation led to inventory improvements for the years beginning with 2006.

5.2.5 Source-specific recalculations (3.A-3.C & 3.D)

On the basis of the results of the aforementioned research project (cf. numeral 5.2.4 "Source-specific quality assurance / control and verification"), source-specific recalculation of NMVOC emissions has been carried out for the years 2006 through 2008. With respect to 2008, that projection yielded an emissions reduction of about 6 %.

As part of the same effort, the report-relevant source categories in this area have been more finely differentiated, on the basis of the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009. As a result, the inventory now includes the following separate subcategories:

3.A.1 Decorative coating application

3.A.2 Industrial coating application

3.A.3 Other coating application

3.B.1 Degreasing

3.B.2 Dry cleaning

3.C Chemical products

3.D.1 Printing industry

3.D.2 Domestic solvent use

3.D.3 Other product use - other

Since compatibility with EU greenhouse-gas reporting is the primary methodological backdrop for conversion of NMVOC emissions into indirect CO₂ emissions, for the current report we have used the reference approach proposed in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. A recalculation of indirect CO₂ emissions has been carried out for the entire time series.

Table 112: Source-specific recalculations, in 3.A-D, for NMVOC emissions from solvents

Source category	Status	Gas	Units	2005	2006	2007	2008	2009
3 A, Paint application	Subm. 2010	NMVOC	Gg	346	305	298	298	
3 A, Paint application	Subm. 2011	NMVOC	Gg	346	318	287	268	268
	Difference	NMVOC	Gg	0	13	-11	-30	
3 B, Degreasing and dry cleaning	Subm. 2010	NMVOC	Gg	43	45	43	43	
3 B, Degreasing and dry cleaning	Subm. 2011	NMVOC	Gg	43	46	47	46	46
	Difference	NMVOC	Gg	0	1	4	3	
3 C, Chemical products, manufacture and processing	Subm. 2010	NMVOC	Gg	47	49	48	48	
3 C, Chemical products, manufacture and processing	Subm. 2011	NMVOC	Gg	47	45	43	54	54
	Difference	NMVOC	Gg	0	-4	-5	6	
3 D, Other product use	Subm. 2010	NMVOC	Gg	307	325	326	326	
3 D, Other product use	Subm. 2011	NMVOC	Gg	307	338	329	301	301
	Difference	NMVOC	Gg	0	13	3	-25	

Table 113: Source-specific recalculations, in 3.A-D, for CO₂ equivalents of solvent emissions

Source category	Status	Gas	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3 A, Paint application	Subm 2010	CO2	Gg	1,595	1,560	1,440	1,440	992	1,116	1,120	1,158	1,197	1,069
3 A, Paint application	Subm 2011	CO2	Gg	1,188	1,144	1,056	1,056	728	819	821	849	878	784
	Difference	CO2	Gg	-407	-416	-384	-384	-265	-298	-299	-309	-319	-285
3 B, Degreasing and dry cleaning	Subm 2010	CO2	Gg	315	342	342	342	126	121	115	122	129	129
3 B, Degreasing and dry cleaning	Subm 2011	CO2	Gg	251	251	251	251	92	88	85	90	95	95
	Difference	CO2	Gg	-64	-91	-91	-91	-34	-32	-31	-33	-35	-35
3 C, Chemical products, manufacture and processing	Subm 2010	CO2	Gg	193	210	210	210	296	274	252	272	292	216
3 C, Chemical products, manufacture and processing	Subm 2011	CO2	Gg	154	154	154	154	217	201	185	199	214	158
	Difference	CO2	Gg	-39	-56	-56	-56	-79	-73	-67	-72	-78	-57
3 D, Other product use	Subm 2010	CO2	Gg	1,206	1,290	1,278	1,278	1,251	1,275	1,298	1,310	1,321	1,288
3 D, Other product use	Subm 2011	CO2	Gg	959	946	937	937	917	935	952	960	969	944
	Difference	CO2	Gg	-246	-344	-341	-341	-334	-340	-346	-349	-352	-343
Source category		Gas	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3 A, Paint application	Subm 2010	CO2	Gg	942	874	932	894	1,029	1,038	915	893	893	
3 A, Paint application	Subm 2011	CO2	Gg	691	641	684	656	755	761	699	632	589	589
	Difference	CO2	Gg	-251	-233	-249	-238	-274	-277	-216	-261	-303	
3 B, Degreasing and dry cleaning	Subm 2010	CO2	Gg	129	128	127	127	127	129	135	129	129	
3 B, Degreasing and dry cleaning	Subm 2011	CO2	Gg	95	94	93	93	93	95	101	104	101	101
	Difference	CO2	Gg	-35	-34	-34	-34	-34	-34	-34	-24	-28	
3 C, Chemical products, manufacture and processing	Subm 2010	CO2	Gg	139	119	132	140	139	141	148	144	144	
3 C, Chemical products, manufacture and processing	Subm 2011	CO2	Gg	102	87	97	102	102	103	99	95	119	119
	Difference	CO2	Gg	-37	-32	-35	-37	-37	-38	-49	-49	-26	
3 D, Other product use	Subm 2010	CO2	Gg	1,255	1,146	1,005	947	922	920	974	977	977	
3 D, Other product use	Subm 2011	CO2	Gg	920	840	737	694	676	675	743	724	663	663
	Difference	CO2	Gg	-335	-306	-268	-253	-246	-245	-231	-253	-314	

5.2.6 Planned improvements (source-specific) (3.A-3.C & 3.D)

No further improvements are planned at present.

5.3 Other – use of N₂O (3.D)

CRF 3.D (N ₂ O)					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
Total solvent and other product use	- / t	N ₂ O	0.16 %	0.03 %	-83.7 %

The source category *Solvents and other product use* is a key category for N₂O emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (- 83.7 %), and thus an extremely low emissions level has been attained (in 2009, emissions amounted to 9.3 % of the contribution of the smallest key source identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply to this source category the more stringent methods that are required for key sources.

5.3.1 Narcotic use of N₂O (3.D.1)

5.3.1.1 Source category description (3.D.1)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF) N ₂ O as anaesthetics						CS				
EF uncertainties in %										
Distribution of uncertainties						N				
EF-determination method						CS				

The German nitrous oxide market is dominated by Air Liquide, Linde AG and Westfalen AG, all of which are leading producers as well as importers. No nitrous oxide emissions occur in nitrous oxide production and in filling of the gas into gas bottles. Emissions occur solely in use of the gas. Medical applications represent the most important N₂O-emissions source. Other emissions sources include use of laughing gas as a propellant in whipped-cream aerosol cans and use in the semiconductor industry. N₂O is also released, in small amounts, in blasting.

Medicine – anaesthesia

In medicine, nitrous oxide, a gas with analgesic properties, is used for narcotic purposes. In such applications, nitrous oxide is mixed with pure oxygen, to produce an active gas mixture consisting of 70 % nitrous oxide and 30 % oxygen. In modern anaesthesia, the effects of nitrous oxide are enhanced through addition of other narcotics. While medical use of N₂O is not prohibited, there is strong resistance – especially in the German medical sector – against widespread, general use of the substance. Medical use of laughing gas has thus been decreasing continuously since 1990.

Food industry – whipped-cream aerosol cans

In the food industry, nitrous oxide is used as an additive known as "E 942". Foods sold in pressurised containers are extracted from such containers with the help of propellants. As it

exits such a container, a food takes on either a foamy or a creamy consistency, depending on what type of food it is. Examples of food to which N₂O is added include whipped cream (from aerosol cans), the dairy product known in Germany as "quark", and various types of desserts, such as ready-to-eat puddings. (DIE VERBRAUCHER INITIATIVE E.V, 2005; LINDE GAS GMBH, 2005)

Semiconductor manufacturing

A wide range of different chemicals and gases is used in semiconductor production. Argon, ultra-pure oxygen, hydrogen, ultra-pure helium and nitrogen account for the lion's share of the gases used. Special process gases, such as nitrous oxide (dinitrogen monoxide), ammonia and hexafluorethane, are used only in relatively small amounts, and the amounts involved have remained nearly constant over the past few years (AMD Saxony LLC&Co. KG, Dresden, Umweltbericht (environmental report) 2002/2003, page 16).

Explosives

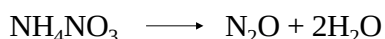
Explosives are used in both military and industrial contexts. Civil and commercial explosives are used in mining, in construction in rocky terrain, in demolition, in geology and in fireworks.

Nitrous oxide emissions occur primarily in detonation of explosives that contain ammonium nitrate, such as ANFO (ammonium nitrate / fuel oil) and emulsion explosives. In general, commercial / civil explosives consist to some 60 to 80 % of ammonium nitrate (AN). By contrast, Andex, an ANFO explosive, contains up to 94 % ammonium nitrate.

In Germany, two companies produce explosives for civil use: Orica Mining (formerly Dynamit Nobel) and Westpreng GmbH (Wasag Chemie).

While no nitrous oxide emissions occur in manufacturing of explosives, nitrous oxide can form in thermal decomposition of explosives. The reason for this is that ammonium nitrate (AN) forms nitrous oxide (laughing gas) and water as it decomposes thermally.

Under careful warming to a temperature above the melting temperature, the reaction is as follows:



But in a fast, detonative reaction of an AN-containing explosive, the reaction occurs as follows:



This means that under high pressure and temperature AN primarily forms nitrogen, oxygen and water as it reacts. Only a small concentration of primarily formed N₂O remains intact in the detonation process. For example, detonation clouds of amatols⁵⁵, which contain some 80 % AN, have only 0.1 mole N₂O per mole of ammonium nitrate. From this figure, a theoretical maximum of about 68 g (this figure was provided by an explosives expert; the stoichiometric value would be 44 g/mole amatol(80 %-AN)) per kilogramme AN can be calculated (ORELLAS, D.L., 1982; VOLK, F, 1997, page 74). According to experts, this AN-content figure can be used as a basis for assumptions regarding N₂O emissions for other explosives.

⁵⁵ Amatol x/y : military explosives. pourable mixtures, i.a. of x % TNT and y % ammonium nitrate

N₂O in auto tuning

In automotive technology, nitrous oxide is used to improve combustion in gasoline / petrol engines, via so-called "laughing-gas injection". In the process, laughing gas is broken down into nitrogen and oxygen. The nitrogen cools the combustion process, and the oxygen increases combustion power. This "tuning" tactic can quickly increase engine performance. To date, one company in Germany offers such tuning measures. Research has shown that the technology used for such tuning is designed to consume the input laughing gas completely, without producing significant emissions.

5.3.1.2 Methodological issues (3.D.1)

Anaesthesia

The 1990 figure for N₂O emissions from medical applications is based on an extrapolation of a statistical plant survey conducted in 1990 in the territory of the former GDR. At the time, it was ascertained that one plant for the production of N₂O for narcotic purposes had existed in the former GDR. Also at the time in question, the plant had not yet been operational for long (it was constructed in 1988). The annual production capacity was approximately 1,200 t. Research indicated that there were no exports or imports of this substance, and thus it was assumed that all of the substance was used for domestic consumption. Via the per-capita emissions calculated from this for the former GDR, and assuming identical conditions, N₂O emissions of 6,200 t were estimated, as a rough approximation, for Germany in 1990. The N₂O figure for 2001 was obtained via a written memorandum, dating from 2002, of the Industriegaseverband e.V. (IGV) industrial-gas association. That figure was tied to a range of 3,000 ~ 3,500 t/a. The mean value from that range (3,250 t/a) was then used for generation of an N₂O-emissions time series.

Since 2005, the Industriegaseverband (IGV) industrial-gas association has carried out surveys of N₂O sales for all applications in Germany. In addition, the IGV has made the data from those surveys available to the Federal Environment Agency for reporting purposes. In 2010, the IGV entered into a voluntary agreement, with the Federal Ministry of Economics and Technology (BMWi), regarding annual provision of N₂O-sales data for purposes of emissions reporting.

The gaps in the data relative to uses in anaesthesia are closed via interpolation and extrapolation.

The pertinent emission factor is 100%.

Whipped-cream aerosol cans

Use of N₂O in aerosol cans for whipped cream, in Germany, has to be carefully differentiated. In Germany, there is one maker of aerosol cans for whipped cream. That maker also fills the cans in Germany. In emissions calculations, it is assumed, on the basis of the above-described research, that that company accounts for a share of about 3 % of the laughing-gas sales of the IGV industrial-gas association. The majority of the companies who deal with such aerosol cans has them filled abroad and then imports them into Germany. The relevant sales of such companies are thus not included in the data of the IGV industrial-gas association. The MIV dairy-industry association has reported to the Federal Environment Agency the results of a one-time survey that showed that 50.2 million units of whipped-cream aerosol cans were sold in 2008. At the same time, the MIV association reported that the units

involved vary in size, and that it is not possible to break the figures down by can sizes. Internet research showed that pressurized cartridges for this area are sold in Germany: cartridges with 8g of N₂O, for 0.5l cans, and cartridges with 16g of N₂O, for 1.0l cans. Comparison calculations have shown that 8g of N₂O is a safe approximation, for purposes of calculation, for the amount of laughing gas contained per sold unit (whipped-cream aerosol can). That, in turn, leads to an input figure of 401.6 t N₂O for whipped-cream aerosol cans in 2008 in Germany. Since no pertinent data are available for the years prior to 2008, that value is assumed to be constant.

The emission factor for whipped-cream aerosol cans is assumed to be 100%.

Semiconductor manufacturing

On a one-time basis, the German Electrical and Electronic Manufacturers' Association (ZVEI) has provided information on quantities of laughing gas sold in the years 1990, 1995, 2000, 2001 and 2008. Values between those points are obtained via interpolation.

In addition, the ZVEI estimated the emission factor for 2008 to be about 40 %, in keeping with conversion of laughing gas within the pertinent process and with downstream treatment processes. The ZVEI was unable to provide any figures for 1990. But since it can be assumed that levels of waste-gas treatment in 1990 were not nearly as high as they were in 2008, an emission factor of 100 % is used as a conservative estimate for 1990. The emission factor for the period between 1990 and 2008 was obtained via interpolation.

Explosives

In 2003, a total of 59 kt of explosives was produced in Germany. Of that figure, 13 kt were exported abroad, and 5.8 kt were imported into Germany⁵⁶. Those figures, in turn, yield a figure of 51.8 kt for the amount of explosives used in Germany. Of that amount, ANFO accounts for a share of 60 %, emulsion explosives account for 25 % and dynamite explosives account for 15 %. ANFO explosives consist of 94 % ammonium nitrate and 6 % fuels. The corresponding relationship for emulsion explosives is 80 % to 20 %; for dynamite explosives, it is 50 % to 50 %.

At present, nitrous oxide amounts in detonation clouds are not determined, while amounts of NO and NO₂ are determined.

Normally, N₂O formation plays a significant role only in explosives that contain ammonium nitrate (AN). That said, no precise analyses of detonation clouds of ANFO explosives have been carried out. For this reason, it must be assumed that the N₂O concentrations formed upon detonation of ANFO are similar, with regard to AN content, to those formed upon detonation of amatols and ammonites⁵⁷, for which analyses have been carried out that support relevant estimates. The following result has been obtained: upon detonation, amatols and ammonites form about 0.1 mole N₂O per mole of ammonium nitrate (AN).

According to the *Federal Office for Material Research and Testing* (BAM), levels of explosives use in Germany remained constant from 1990 to 2005.

⁵⁶ Personal communication: Federal Office for Material Research and Testing (BAM).

⁵⁷ Ammonite: Composition: 70-88 % ammonium nitrate, with 5-20 % nitroaromates, 1-6 % vegetable flour and, in some cases, 4 % nitroglycerine, aluminium powder and potassium perchlorate

The emission factor for use of explosives is 0.1036 kg N₂O/t explosives. That emission factor was determined, via measurement, by the BAM in February 2010. As a result, the emission factor has been corrected downward, considerably, with respect to the Submission 2010.

5.3.1.3 Uncertainties and time-series consistency (3.D.1)

Since 2005, activity data for narcotic / anaesthetic uses have been obtained from association information. For that reason, the uncertainty is estimated to be 20 %. The data on consumption for whipped-cream aerosol cans are subject to a very high level of uncertainty (75 %), since the relevant calculation is based on several assumptions and since a definite figure is available only for 2008. The uncertainty of the activity data for the semiconductor industry is estimated at 10 %, since the data have been obtained from facility operators themselves.

The uncertainty in the emission factors for anaesthesia and whipped-cream aerosol cans is set as 0 %, since at present it is assumed that N₂O undergoes no transformation in use, and that the gas thus escapes completely into the atmosphere following its use. The emission factor for use in semiconductor manufacturing is estimated to have an uncertainty of 15 %, since the data have been obtained from facility operators themselves. The emission factor for explosives is estimated to have an uncertainty of 5 %, since the emission factor has been determined via an official measurement.

With these results, the time series can be considered to show a normal distribution (distribution type).

5.3.1.4 Source-specific quality assurance / control and verification (3.D.1)

Quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

Data were taken from previous years or determined on the basis of existing calculation routines.

The figures for 2001 were obtained via direct enquiry of the IGv; as a result, the data for that year can be considered to be of higher quality. No data verification was carried out for the other years in question.

5.3.1.5 Source-specific recalculations (3.D.1)

The emission factor for explosives was reduced from 3.4 to 0.1036 kg N₂O/t explosives, as a result of measurements made in February 2010 by the Federal Institute for Materials Research and Testing (BAM) (cf. Table 114).

Table 114: Recalculation for explosives

Source category	Status	Gas	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Use of explosives	Resubmission 2010	N ₂ O	t	176.1	176.1	176.1	176.1	176.1	176.1	176.1	176.1	176.1	176.1
Use of explosives	2011 submission	N ₂ O	t	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	Difference	N ₂ O	t	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8
Source category	Status	Gas	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Use of explosives	Resubmission 2010	N ₂ O	t	176.1	176.1	176.1	176.1	176.1	176.1	176.1	176.1	176.1	
Use of explosives	2011 submission	N ₂ O	t	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	Difference	N ₂ O	t	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	-170.8	

Table 115: Recalculation of laughing-gas emissions from narcotic uses

Source category	Status	Gas	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Narcotic uses	Resubmission 2010	N ₂ O	t	6,200.0	5,931.8	5,663.6	5,395.5	5,127.3	4,859.1	4,590.9	4,322.7	4,054.6	3,786.4
Anaesthetics	2011 submission	N ₂ O	t	6,200.0	5,931.8	5,663.6	5,395.5	5,127.3	4,859.1	4,590.9	4,322.7	4,054.5	3,786.4
Anaesthetics	Difference	N ₂ O	t	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Source category	Status	Gas	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Narcotic uses	Resubmission 2010	N ₂ O	t	3,518.2	3,250.0	3,250.0	3,250.0	3,250.0	3,250.0	3,250.0	3,250.0	3,250.0	
Anaesthetics	2011 submission	N ₂ O	t	3,518.2	3,250.0	2,761.7	2,273.4	1,785.1	1,296.7	1,342.0	1,222.4	1,054.3	968.9
Anaesthetics	Difference	N ₂ O	t	0.0	0.0	-488.3	-976.6	-1,464.9	-1,953.3	-1,908.0	-2,027.6	-2,195.7	

The emissions from whipped-cream aerosol cans have been recalculated, and laughing gas from imported cans has also been taken into account, along with use of cans filled in Germany.

For the area of anaesthesia, the data for the period as of 2002 have been recalculated, on the basis of the data provided by the IGV industrial-gas association (cf. Table 115).

The N₂O emissions from the semiconductor industry were recalculated for the entire time series, since the ZVEI provided new input data for the entire period, as well as a new emission factor for 2008.

The resulting changes for whipped-cream aerosol cans and the semiconductor industry cannot be shown in tabular form, since the pertinent emissions are reported in aggregated form, together with emissions data from N-dodecandiacid production (2.B.5), and the latter data include confidential data.

5.3.1.6 Planned improvements (source-specific) (3.D.1)

No improvements are planned at present.

6 AGRICULTURE (CRF SECTOR 4)

6.1 Overview (CRF Sector 4)

6.1.1 Source categories and total emissions, 1990 - 2009

In Germany, source category 4, "Agriculture", includes Enteric fermentation (4.A), Manure management (4.B) and Agricultural soils (4.D).

Emissions from rice cultivation (4.C) do not occur in Germany, while clearance of land by prescribed burning (4.E) is not practiced in Germany (NO). Field burning of agricultural residues (4.F) is prohibited in Germany, although it must be noted that some exemptions are permitted, and these do not lend themselves to surveys. Such exceptions are considered to be irrelevant (NO).

For the present NIR 2011, Figure 1 provides an overview of the development of greenhouse-gas emissions, over time, in the areas 4.A, 4.B and 4.D. The pertinent data were calculated with the GAS-EM model described in chapters below (cf. Chapter 6.1.3). Such calculation has taken account of changes on which the Resubmission 2010 (cf. Chapter 6.1.2) is based.

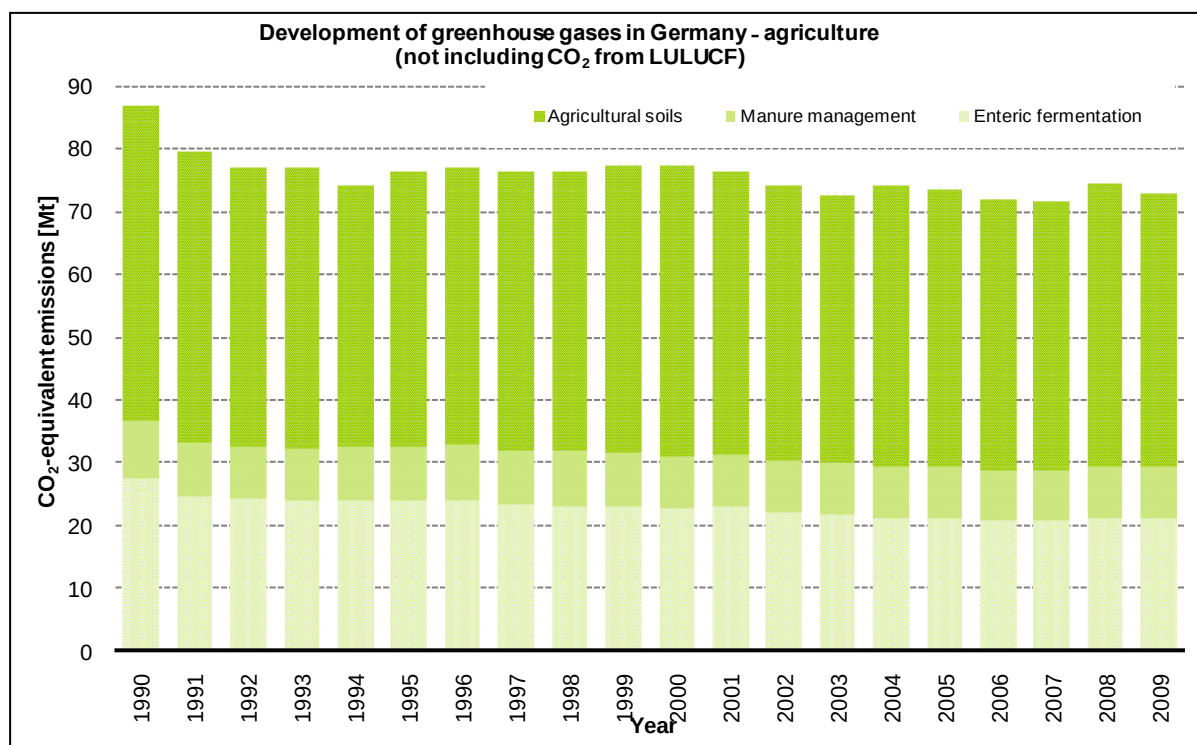


Figure 43: Overview of greenhouse-gas emissions in CRF Sector 4

6.1.2 Resubmission 2010

An in-country review of the NIR 2010 was carried out in September 2010. On the basis of that review, a Resubmission 2010 was prepared; cf. the backward-projections chapter 10.5.

For the Resubmission 2010, in the area of agriculture (Sector 4) modifications were carried out in calculation of CH₄ emissions from enteric fermentation in dairy cows (4.A) and from manure management (4.B), as well as in calculation of indirect N₂O emissions from leaching and surface runoff (4.D). In the Resubmission, the modified input figures and recalculated emissions data replace the corresponding figures and data in the NIR 2010. As a result of the

recalculations, in the Resubmission the total emissions in areas 4.A, 4.B and 4.D differ from the corresponding values in the NIR 2010.

The other data presented in the NIR 2010 were retained, unchanged, in the Resubmission 2010. In the interest of avoiding any confusion, in the present NIR 2011 comparisons of results with last year's inventory results are oriented, as a rule, to the data presented in the Resubmission 2010.

6.1.3 *The GAS-EM emissions-inventory model*

6.1.3.1 Aims

Emissions calculation in source category 4 "Agriculture" supports fulfillment of international greenhouse-gas-reporting obligations under the UNFCCC, the Kyoto Protocol and related regulations at the European level. It also has a function in advising of the political sector, in that it facilitates identification and quantification of sinks for / sources of climate-harming gases, in the agricultural sector, as well as identification and quantification of emissions-reducing measures and of interactions between directly and indirectly active climate-relevant gases. Its purposes thus include quantifying the relevant costs.

The German emissions calculations for the gases methane (CH₄), non-methane volatile organic compounds (NMVOC), ammonia (NH₃), nitrous oxide (N₂O) and nitrogen monoxide (NO) from agricultural sources have been carried out with the help of the GAS-EM (Gaseous Emissions) inventory model.

The GAS-EM model provides a consistent basis for international reporting obligations in the agriculture sector (vTI-AK 2009). The GAS-EM model is designed to achieve the following:

- to describe agricultural production in Germany in the most current, detailed and accurate manner possible,
- to take account of Germany's diversity of agricultural systems,
- to take account of trends in yields, technology and management,
- to take account of changes in relevant legislation,
- to provide a spatially differentiated basis for cost calculations.

6.1.3.2 Guidelines applied, and detailed report

The GAS-EM emissions-inventory model is based on implementation of the relevant sets of guidelines (UN ECE: EMEP, 2003; EMEP, 2006; EMEP, 2009; IPCC Guidelines: IPCC, 1996b; IPCC 2006, IPCC Good Practice Guidance and Uncertainty Management [IPCC GPAUM]: IPCC, 2000). The reasons why parts of IPCC Guidelines that had not yet been adopted (IPCC Guidelines, 2006) were used instead of the otherwise applicable IPCC Guidelines (1996b) are presented in Chapter 19.4.1.

As of the 2010 Resubmission, Germany implemented the calculation-methods modifications required as a result of the in-country review (cf. Chapter 6.1.2 and 0). Since then, Germany has assumed that the calculation basis for the GAS-EM inventory model has been internationally accepted. This applies especially to use of the Guidelines IPCC (2006), on a by-case basis, since the reasons presented in Chapter 19.4 of the NIR 2010 were not criticised during the in-country review or in the Saturday-Letter. By contrast, in the draft of the final review report, the ERT requested that either the reasons be improved or that a return be made to the Guidelines IPCC (1996b) or the IPCC Good Practice Guidance (IPCC, 2000).

For the present Submission 2011, Germany is unable to fulfill that request, since the draft of the final report arrived at such a late date (16 February 2011) that no time was left for adequate processing of the ERT recommendations.

Over the past few years, many of the methods described in the guidelines have been refined for purposes of GAS-EM. A comprehensive description of the GAS-EM inventory model, including listings of relevant additional sources, is presented in the pertinent detailed report (RÖSEMANN et al., 2011). The following remarks summarise the detailed report with regard to the aims for the NIR 2011. The detailed report will go to print in early 2011⁵⁸.

The following chapters on the methods used in sectors 4.A, 4.B and 4.D (chapters 6.2.2.1, 6.3.2.2.1, 6.3.3.2.1, 6.3.4.2.1 and 6.5.2) present an overview of the manner in which GAS-EM functions. The procedures used in the area of animal husbandry are described specifically in Chapter 6.3.4.2.1, while Chapter 6.5.2 covers methods for the area of agricultural soils.

6.1.3.3 Basic structure of the GAS-EM emissions-inventory model

Emissions from animal husbandry are calculated on the basis of feed intake, which, in turn, is calculated as necessary in accordance with yield (Figure 44). That approach provides the CH₄ emissions from enteric fermentation (4.A), as well as the carbon and nitrogen excretions data needed to calculate emissions from manure management (4.B). The latter, in turn, enter into calculations of nitrogen discharges into agricultural soils (4.D).

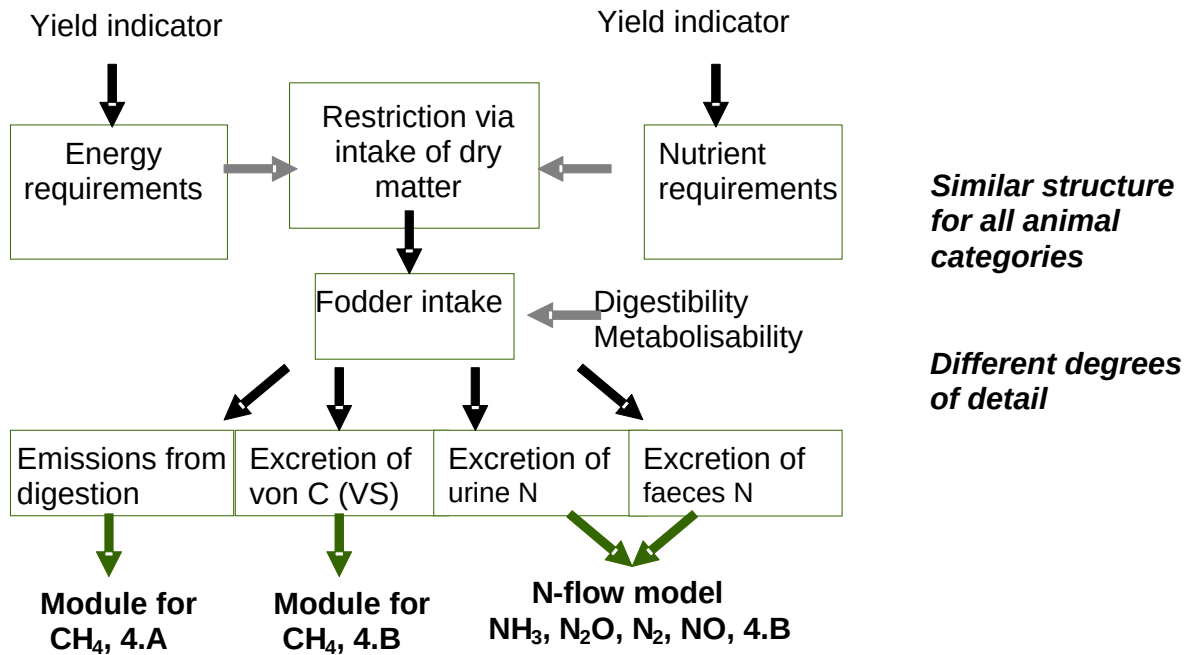


Figure 44: Logical structure behind national methods for calculating emissions from animal husbandry

Figure 45 illustrates how, and on what spatial level (depending on data availability), the GAS-EM model, for calculation of emissions from source categories 4.A and 4.B, first breaks the sector down by animal categories and sub-categories, and then breaks those categories / sub-categories down by stall systems, storage systems and manure-application procedures.

⁵⁸ The detailed report is also be available in electronic form at: claus.roesemann@vti.bund.de, dieter.haenel@vti.bund.de.

CH₄ emissions are calculated separately for each animal sub-category in 4.A and 4.B. For source categories 4.B and 4.D, N₂O emissions are calculated on the basis of an N-flow concept (cf. Chapter 6.1.3.4).

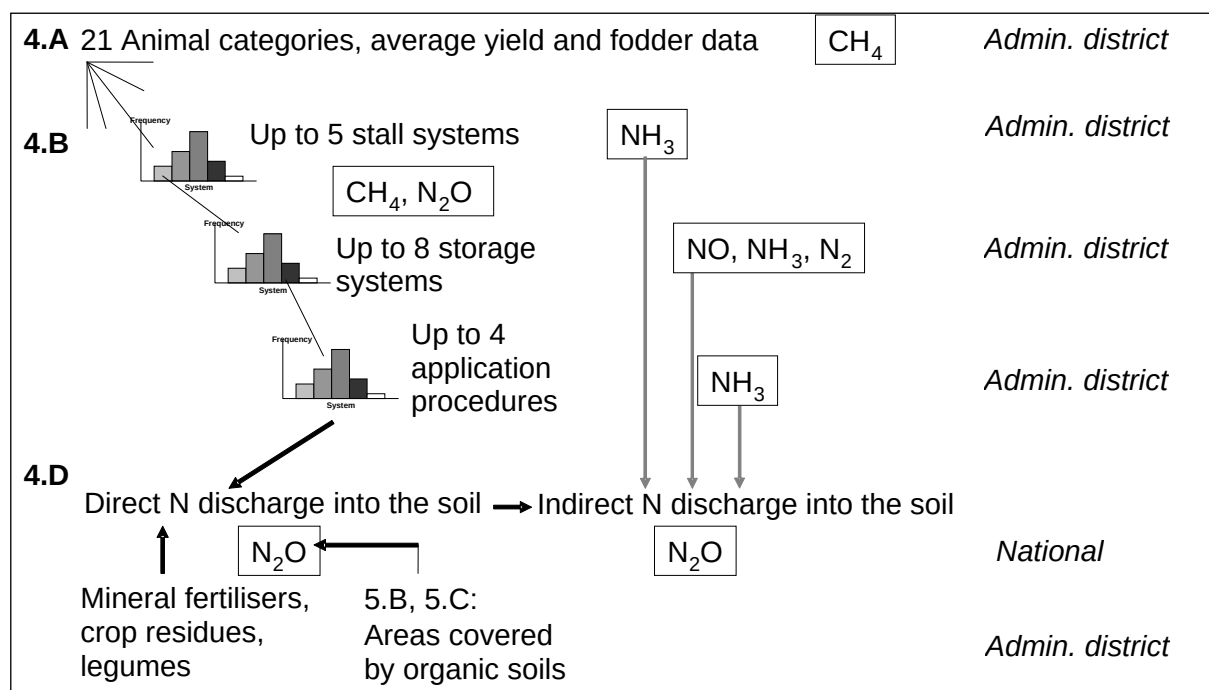


Figure 45: The GAS-EM model: basic concept, thematic content and spatial resolution

6.1.3.4 The N-flow concept

With the GAS-EM model, N-species emissions are calculated on the basis of the N-flow concept (Dämmgen and Hutchings, 2005, Figure 3).

To make it possible to apply the concept, the N quantities excreted in animal husbandry have to be determined. For dairy cows, heifers, fattening bulls, swine, laying hens, pullets, broilers, ducks and turkey cocks and hens, N excretions are calculated as a function of yield (annual milk production or egg production (i.e. numbers of eggs); weight gain) and, if relevant, numbers of young. For other animals, N-excretion data are taken from the pertinent German literature (cf. the references in RÖSEMANN et al., 2011).

In the case of N excretions, a distinction is made between the two fractions "organic N" and "TAN readily converted into NH₃" ("total ammoniacal nitrogen"). TAN is present in the urine of mammals; in the inventory model, in each case TAN is considered to be equivalent to the N content of urine. Poultry excrete "UAN" (uric acid nitrogen); in the inventory, UAN is treated as TAN. In calculation of N emissions from different stations throughout the spectrum from animal N excretions and N discharges into the soil, two N pools are carried throughout the calculations: the total N quantity present within the relevant station, and the fraction of that quantity that is present as TAN. As a result of the manner in which the relevant emission factors are defined, NH₃ emissions are calculated in proportion to the pertinent TAN quantity present, while N₂O emissions, NO emissions and N₂ emissions (the last of which are also relevant within the N-flow concept) are calculated in proportion to the total quantity of N present.

The N excretions determined for a given animal category are divided into grazing emissions and stall emissions. The line between the two categories is drawn on the basis of the

duration of the grazing periods, the average daily duration of grazing and, for cows, the average daily time spent in the milking stall.

In the case of solid-manure systems, N inputs from straw bedding are also taken into account, along with N excretions.

For each animal category, the quantities of N occurring in stalls are divided in accordance with the relative shares of the animal-keeping procedures commonly used in Germany, which procedures vary in terms of their emissions behaviour. In stalls, losses of N from excreted quantities of N result, via emissions of NH_3 . (Below, N_2O emissions are calculated jointly for stalls and storage facilities.) Following deduction of NH_3 emissions from stalls, the N quantity remaining for all stalls is combined and transferred to the storage-facilities category.

The total quantity of N added to storage facilities is divided among the storage procedures commonly used in Germany, in accordance with the applicable percentage shares for the different procedures. That procedure includes a breakdown by solid and liquid farm manures. It does not take the following procedures / storage types into account (because they are not commonly used in Germany): open lagoons, daily application and incineration of farm manure for energy recovery. Emissions of NH_3 , N_2O , NO and N_2 are emitted from storage facilities. The quantity of N remaining in the various storage systems, following deduction of N emissions, is combined and added to the "application" category.

The quantity of N applied is divided among the application procedures commonly used in Germany, in accordance with the applicable percentage shares for the different application procedures and periods required to work manure into the soil; different emission factors apply to different such procedures and periods. In manure application, N losses occur via NH_3 emissions. Deduction of NH_3 emissions, and of the NO emissions calculated in proportion to applied quantities of N, yields the N quantity resulting from manure application, the quantity of available N used to calculate direct N_2O emissions in this area.

6.1.4 Characterisation of animal stocks

6.1.4.1 Animal categories (CRF 4.A, 4.B)

For calculation of emissions from animal husbandry in German agriculture, animal stocks are divided into main categories and sub-categories. Division into sub-categories is required to permit adequate description of sub-stocks that are homogeneous with regard to yield and to forms of keeping. The following table compares the German sub-categories and the IPCC proposals.

Table 116: Characterisation of animal stocks pursuant to IPCC, and the pertinent breakdown used for purposes of German emissions reporting

	IPCC main categories	IPCC sub-categories	Germany		
Cattle	Dairy cows	Subdivision into two or more yield classes	Dairy cows, yield-/feed-oriented survey for each rural district		
	Adult cattle, "other"	Male/female fattening and additions, pulling power	Suckling cows		
			Stud bulls (mature males)		
	Young animals	Heifers, calves, young male cattle	Calves		
			Young female cattle (heifers)		
Young male cattle (fattening bulls)					
Swine	Mature swine	Pregnant sows Farrowing sows	Sows (including suckling pigs weighing up to 8.5 kg)		
		Boars	Boars		
	Growing swine	Suckling pigs Fattening pigs Replacement	Weaned piglets		
			Fattening pigs		
Sheep	Ewes	Pregnant ewes Dairy sheep	CH ₄ : Sheep	N species, NMVOC: Sheep, not including lambs; lambs	
	Sheep >1 year	---			
	Young animals	Male animals, castrated animals, female animals			
Poultry	Chickens	Laying hens in liquid-manure and solid-manure systems Free-range farming, broilers	Laying hens		
			Broilers		
			Young hens (pullets)		
	Turkeys	Turkeys for breeding Turkeys in stall husbandry Turkeys in free-range husbandry	Male fattening turkeys		
			Female fattening turkeys		
Ducks	Ducks for breeding Fattening ducks	Fattening ducks			
Other	Other	Horses, goats, donkeys, mules, camels, fur-bearing animals, geese, etc.	Horses (large and small horses), goats, donkeys and mules, fur-bearing animals, buffalo, geese		

Columns 1 and 2 pursuant to IPCC (2006)

In German reporting, the animal category "cattle" (CRF 4.A.1.A) consists of dairy cows (CRF 4.A.1.a) and "other cattle" (CRF 4.A.1.b). "Other cattle" include calves, heifers, fattening bulls, suckling cows and stud bulls.

The category "swine" (CRF 4.A.8) is divided into sows (including suckling pigs weighing up to 8.5 kg), weaned piglets, fattening pigs and boars.

For calculation of methane emissions, the category "sheep" (CRF 4.A.3) is not divided into sub-categories, due to a lack of suitable emissions-explaining variables. For calculation of emissions of nitrogen species and NMVOC, sheep are divided into the sub-categories of lambs and sheep (not including lambs). The results are reported in aggregated form, for "sheep".

The category "poultry" (CRF 4.A.9) is divided into the categories of laying hens, broilers, young hens (pullets), geese, ducks, male turkeys and female turkeys. For turkeys, male and female birds differ so markedly in terms of feeding and weights that they have to be considered separately.

For "horses" (CRF 4.A.6), large horses and small horses are considered separately, since the two groups differ in terms of their energy requirements. The results for the two categories are aggregated to form the total results for the category "horses".

6.1.4.2 Activity data (CRF 4.A, 4.B)

The activity data for Germany refer not to animals but to animal places used for production. The numbers of animal places used for production, are taken, where available, from official German agricultural statistics. The underlying animal censuses cover all cattle, all pigs, horses and sheep and all poultry.

Animal census results for German districts are available for every second year in the period until 2003 and for 2007. For the years in between and thereafter, the relevant animal head counts are available only at the Länder level. For reasons of data protection, unpublished district-level data records are incomplete. In co-operation with the Federal Statistical Office, calculations with the GAS-EM model as of 2007 were carried out with inclusion of data that must be kept confidential.

In the period since 1990, the Agricultural Statistics Act (Agrarstatistikgesetz), which defines the framework for collection of German official agricultural statistics, has been amended a number of times. The amendment of 1998 had a particularly profound effect with regard to preparation of emissions inventories. Its changes in the areas of counting thresholds and survey times especially affected the applicable numbers of horses and sheep. As a result, Dämmgen (2005) had developed corrections of horse counts as of 1999, on the basis of expert estimates. By agreement with the Federal Statistical Office and the Federal Environment Agency, those corrections, which were used until the 2010 Resubmission, will no longer be used as of the present NIR 2011, since only horses counted in agricultural surveys are relevant for calculation of agricultural emissions and only those figures are actually known. The numbers of horses have decreased as a result. As a result of the discontinuation of use of the corrections, the ratio of large horses to small horses / ponies has changed slightly, and that change slightly modifies the results averaged over all horses.

The head-count correction derived by DÄMMGEN (2005) for sheep in the years 1990 through 1998 (conversion of overly low November head counts into higher May head counts) is no longer being used at the national level, since the Federal Statistical Office has now provided June head counts for 1990 through 1998, and June head counts are considered to be an equivalent substitute for the lacking May figures.

Since the preparation of the NIR 2009, the figures for cattle have been taken from a special database ("origin-tracing and information system for animals" (HIT - Herkunftssicherungs- und Informationssystem für Tiere; <http://www.hi-tier.de>) in which every animal is registered. As a result, the relevant numbers of animals for the years as of 2008 are systematically higher than those for earlier years, when, due to the cut-off definitions used, official statistics failed to include all animals concerned. A comparison carried out by the Federal Statistical Office for 2007 revealed that the cattle head counts shown in HIT are 2.9 % higher than those resulting via the conventional survey method (for dairy cows alone, the head counts are 2.8 % higher). It is not possible to estimate, after the fact, the differences for years back to 1990, since the available animal head counts cannot be correlated with farm sizes. Therefore, it is also not possible to correct the time series for cattle head counts for the years 1990 through 2007. Consequently, the reduction in emissions from keeping of cattle that occurred between 1990 and 2009 is being underestimated.

German agricultural statistics do not include head-count figures for goats, mules and asses, fur animals and buffalo. The lacking animal census figures are obtained as described below (the procedures do not apply to head counts for fur animals, for which only a sample calculation - for the year 2000 - can be carried out, and for which constant head counts since 1990 are assumed).

In the past, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) estimated goat populations at the national level. For the period 2005 through 2009, the pertinent time series was continued via estimation by the Federal Statistical Office.

No head-count time series are available for mules and asses. Figures published in 2003 by Interessengemeinschaft für Esel und Maultiere (IGEM, interest association for mules and asses; Deutsches Eselstammbuch (German book of donkey pedigrees), 2003) indicate that some 6,000 to 8,000 donkeys, and about 500 mules and hinnies, were being kept in Germany as of that time. More recent figures from Deutsches Eselstammbuch (2009) are considerably lower. On the other hand, those figures are subject to large uncertainties. For this reason, the head-count figure for mules and asses is assumed to be a constant 8,500.

The relevant figures for buffalo are provided by Deutscher Büffel-Verband (the German Buffalo Association) for the years as of 2000. In keeping with a recommendation in the final report for the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention", the time series for the buffalo population was completed for the years prior to 2000. This was accomplished via linear extrapolation. In the process, arithmetically negative animal populations resulted for the years 1990 to 1995 and were replaced with "zero".

In the case of poultry, the head-count figure resulting for 2008 differs from that reported in the 2010 resubmission. The reason for this is that the then-used method for filling in the missing head count for 2008 (retention of the 2007 value), for the broiler category, was discontinued, in favour of extrapolation.

In the interest of obtaining maximally homogeneous animal categories, some of the officially defined animal categories have to be modified. For this reason, the head-count figures used in the German GAS-EM inventory model for calves, heifers, fattening bulls, weaned piglets, fattening pigs, laying hens and pullets diverge from the relevant figures in the official statistics. In the "turkey" category, roosters and hens have to be considered separately. The totals for all cattle, the sum of the figures for pullets and laying hens, and the sum of the figures for turkey roosters and turkey hens are each in accordance with the official statistics, however. For swine, the total head-count figure used for German emissions reporting is lower, by the number of suckling pigs, than the total figure from official statistics, since suckling pigs weighing up to 8.5 kg per animal are grouped with sows, and the relevant results are assigned solely to sows. As a result of the aforementioned additional data provision by the Federal Statistical Office, for the months of June in the years 1990 through 1998, the total figures for sheep differ from the officially reported figures, which all result from surveys carried out in November.

Table 117 presents a compilation of the animal-place figures on which German reporting is based. With regard to the uncertainties for the animal head counts, cf. Table 123 in Chapter 6.1.6.

Table 117: Animal-place figures used in German reporting (4.A, 4.B)

(in thousands)	Dairy cows	Other cattle	Swine	Sheep	Goats	Horses	Mules and asses	Buffalo	Poultry
1990	6,355	13,133	26,965	3,266	90	491	8.5	0.00	113,879
1991	5,632	11,502	22,598	3,250	86	491	8.5	0.00	113,952
1992	5,365	10,843	23,035	2,999	90	531	8.5	0.00	103,662
1993	5,301	10,597	22,649	3,001	92	531	8.5	0.00	103,735
1994	5,273	10,690	21,529	2,882	95	599	8.5	0.00	109,948
1995	5,229	10,661	20,746	2,991	100	599	8.5	0.00	110,035
1996	5,195	10,565	21,181	2,953	105	652	8.5	0.05	112,507
1997	5,026	10,201	21,628	2,885	115	652	8.5	0.17	112,507
1998	4,833	10,110	22,907	2,869	125	652	8.5	0.30	112,507
1999	4,765	10,131	22,563	2,724	135	476	8.5	0.42	118,303
2000	4,570	9,968	22,182	2,743	140	476	8.5	0.63	118,303
2001	4,549	10,055	22,220	2,771	160	506	8.5	0.63	122,056
2002	4,427	9,560	22,538	2,722	160	506	8.5	0.76	122,056
2003	4,371	9,273	22,777	2,697	160	525	8.5	0.89	123,408
2004	4,285	8,911	22,176	2,714	160	525	8.5	1.02	123,408
2005	4,236	8,799	23,184	2,643	170	500	8.5	1.19	120,562
2006	4,082	8,667	22,857	2,561	180	500	8.5	1.32	120,562
2007	4,071	8,615	23,429	2,538	180	542	8.5	1.54	126,863
2008	4,218	8,752	23,107	2,437	190	542	8.5	1.79	127,503
2009	4,205	8,739	23,445	2,350	220	542	8.5	2.11	128,144

6.1.4.3 Additional information (CRF 4.A, 4.B)

To calculate emissions in accordance with a Tier-2 method, one requires data on animal yield (animal weight, weight gain, milk output, milk protein content, milk fat content, numbers of births, numbers of eggs and weights of eggs) and on the relevant feed (phase feeding, feed components, protein and energy content, digestibility and metabolisability). To divide officially recorded total numbers of turkeys into roosters and hens, one must know the applicable sex ratio. For the most part, such data are not available from official statistics. In the present case, such data were obtained from the open literature, from association publications, from regulations for agricultural consulting in Germany and via surveys of experts. Some data for turkeys were provided by hatcheries.

Data such as frequency distributions relative to feeding, to husbandry methods (shares for grazing/stabling; shares for various housing methods), to types of manure storage and to techniques for applying farm manure were obtained with the help of the RAUMIS agricultural sector model (Regionalisiertes Agrar- und UmweltInformationssystem für Deutschland; Regionalised agricultural and environmental information system for Germany), which is operated and upgraded by the Institute of Rural Studies of the Johann Heinrich von Thünen Institute (vTI, the Federal Research Institute for Rural Areas, Forestry and Fisheries; until 2008, that system was operated by one of the vTI's predecessor institutes, the Bundesforschungsanstalt für Landwirtschaft (FAL - Federal Agricultural Research Centre). For a pertinent introduction, cf. WEINGARTEN (1995); a detailed description is provided in HENRICHSMEYER et al. (1996).

The data that enter into RAUMIS include specialised national statistics at the sectoral and district levels, standardisation data of the Association for Technology and Structures in Agriculture (KTBL-Normdaten) relative to description of production processes, data from the Economic Accounts for Agriculture (EAA), special evaluations of the Federal Ministry of Food, Agriculture and Consumer Protection (herd-size-class distribution) and survey data. Where relevant statistical data are missing, models are formulated with the aid of experts.

The following section presents a compilation of additional animal-husbandry data of key relevance to yields.

Table 118 shows the mean animal weights for dairy cows, other cattle, swine and poultry. Details on calculation of average animal weights are presented in RÖSEMANN et al. (2011). Errors have been corrected in national-level aggregation of animal weights. For dairy cows, other cattle and swine, these corrections have led to higher average animal weights in comparison to the corresponding figures reported in the 2010 resubmission. These changes solely affect the additional information given in the CRF tables; they do not affect the emissions levels, since those were calculated with non-aggregated animal weights for the individual animal sub-categories.

In the case of poultry, updating of the duck-weight figure, and the lower broiler end weights obtained with the new calculation procedure, lead to a lower mean average weight for poultry as of 1998, with respect to the 2010 resubmission. In addition, the pertinent updating and lower end weights have reduced emissions from keeping of ducks and of broilers, respectively.

Table 118: Mean animal weights (4.B)

(kg/animal)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	607.9	599.1	619.3	631.1	623.1	621.8	631.9	626.7	636.2	640.4
Other cattle	300.1	299.3	309.5	314.0	312.8	313.7	319.2	319.1	326.3	326.1
Swine	71.1	69.4	70.2	70.6	71.7	72.7	72.5	72.7	72.2	71.5
Poultry	1.77	1.79	1.81	1.76	1.73	1.71	1.68	1.69	1.72	1.69
(kg/animal)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	644.3	654.0	648.3	644.6	641.3	645.8	647.4	651.3	645.3	642.0
Other cattle	329.6	334.6	329.4	328.8	327.4	326.4	330.6	333.8	327.7	328.4
Swine	71.1	71.2	71.3	71.5	71.6	71.1	71.4	71.8	71.3	71.3
Poultry	1.78	1.81	1.76	1.89	2.02	2.01	1.94	2.01	1.99	1.99

Due to a lack of differentiated data, chronologically and spatially constant weight figures result for the other animal categories (RÖSEMANN et al., 2011): sheep, 50 kg/animal; goats, 40 kg/animal; horses, 490 kg/animal; mules and asses, 245 kg/animal; and buffalo, 700 kg/animal.

Table 119 shows the mean daily milk yield for dairy cows, an important yield parameter.

Table 119: Mean daily milk yield for dairy cows (kg/day) (4.A)

(kg/day)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Milk yield	12.9	13.2	13.8	14.4	14.4	14.9	15.1	15.3	15.6	16.2
(kg/day)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Milk yield	16.6	17.0	17.2	17.9	18.0	18.5	18.8	19.0	18.7	18.7

Table 120 shows the mean pregnancy rates for dairy cows, heifers, suckling cows and sows. For buffalo, an average pregnancy rate of 25 % is assumed. For horses, mules and asses and, sheep and goats, no pertinent figures are available, and thus pregnancy rate is not taken into account as a yield parameter for those animals.

Table 120: Mean pregnancy rates (4.A).

(%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	75.5	74.5	78.1	79.7	79.2	79.2	79.9	79.3	79.1	79.4
Heifers, suckling cows	53.8	54.5	56.7	56.6	57.5	57.9	58.0	58.5	59.2	59.2
Sows	65.7	68.5	66.8	66.2	67.7	68.0	67.6	66.3	68.7	65.9
(%)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	78.1	78.6	76.1	77.1	78.0	77.9	77.8	79.5	79.1	78.5
Heifers, suckling cows	60.0	61.4	60.6	60.9	60.5	60.2	59.7	59.8	59.2	58.7
Sows	68.1	69.7	69.9	69.8	69.5	70.6	71.1	71.9	71.7	71.8

Table 121 shows the daily gross energy intake (GEI) figures, for dairy cows, other cattle and swine, that enter into calculation of CH₄ emissions from enteric fermentation and manure management.

Table 121: Mean daily gross energy intake (GEI) (4.A)

(MJ/animal)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	269.2	274.3	283.7	288.9	288.6	291.7	295.7	297.6	302.2	305.6
Other cattle	101.2	102.7	106.3	107.2	106.0	106.9	107.5	107.2	107.7	108.4
Swine	26.9	27.6	27.8	27.8	28.0	28.3	28.4	28.6	28.9	28.8
(MJ/animal)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	309.8	315.3	317.0	320.5	321.4	325.1	326.8	329.8	326.0	325.9
Other cattle	108.7	109.0	108.3	108.3	107.9	108.2	108.7	109.2	108.6	108.8
Swine	28.9	29.0	29.0	29.1	29.1	29.2	29.3	29.3	29.5	29.8

The relevant changes with respect to the 2010 resubmission are the result of methodological changes (cf. Chapters 6.2.5, 6.3.2.5 and 6.3.4.5).

Table 122 shows feed digestibility for dairy cows, other cattle and swine. The relevant method for calculating the mean value for swine has been changed with regard to the 2010 Resubmission: Since no specific figures are available for suckling piglets weighing up to 8.5 kg per animal - in the GAS-EM inventory model, such piglets are grouped together with sows - such piglets have not been taken into account separately in determination of the mean. That change does not affect emissions calculation, however, since the relevant aggregation is carried out before the mean feed digestibility for swine is calculated.

For other animals, the IPCC default values for feed digestibility are used. IPCC (1996b), Table B-7, provides the relevant figures for sheep (60 %), goats (60 %), horses (70 %) and mules and asses (70 %). For buffalo, IPCC (1996b), Tab. B-5, gives a feed digestibility figure of 55 %.

Table 122: Feed digestibility (4.A)

(%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	74.3	74.5	74.7	74.8	74.6	74.7	74.8	74.8	74.9	75.0
Other cattle	73.3	73.1	72.9	72.7	72.8	72.6	72.5	72.4	72.4	72.3
Swine	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8
(%)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	75.1	75.2	75.2	75.3	75.3	75.4	75.5	75.6	75.5	75.5
Other cattle	72.3	72.3	72.4	72.4	72.4	72.3	72.4	72.4	72.4	72.5
Swine	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8	82.8

The following chapters present further information relative to animal husbandry – for example, excretion data (VS, N) and key data on manure management.

6.1.5 Characterisation of agriculturally used soils

Direct emissions of N₂O in the area of agriculturally used soils occur via application of mineral and farm fertilisers, cultivation of organic soils, grazing, and application of sewage sludges, as well as from crop residues. Indirect N₂O emissions occur as the result of deposition of reactive nitrogen and via nitrogen leaching and surface runoff.

To describe the various emissions-relevant processes at work, one must collect a large range of different types of data. Such required data are described in Chapter 6.5.2.

6.1.6 Total uncertainty of all emissions in Sector 4

Along with emissions calculations, the total uncertainty for all emissions in Sector 4 was calculated; cf. Table 123. That calculation was carried out on the basis of the Tier 1 method described in IPCC GPAUM (2000), "Quantifying Uncertainties in Practice". That procedure, in turn, is based on thorough application of Gaussian error correction. By way of convention, the fact that such error correction assumes a normal distribution is ignored, and the normal-distribution required is not met by - or cannot be checked for - some of the activity data and emission factors that enter into the calculation. Furthermore, Gaussian error calculation is oriented to use of standard errors. In contrast to that orientation, the Tier 1 method described in IPCC GPAUM (2000), "Quantifying Uncertainties in Practice" (cf. p. 6.14 in the paragraph relative to columns E and F), requires entry of half of the 95 % confidence interval, which value amounts to about double the standard error. It can be shown, however, that the calculation rules for Gaussian error calculation (cf. Equ. 6.3 and Equ. 6.4 in IPCC GPAUM, 2000) also apply to multiples of the standard error.

With regard to asymmetric distributions, IPCC GPAUM (2000), "Quantifying Uncertainties in Practice" (p. 6.14), requires, for the Tier 1 method, that the larger of the two intervals [2.5 percentile; mean value] and [mean value; 97.5 percentile] be used. That requirement has been fulfilled.

With regard to the sources for the uncertainty data that enter into the total-uncertainties calculation, and to estimation of the N₂O emission factor for manure management, we refer to RÖSEMANN et al. (2011).

Significantly, the uncertainty for cattle head counts has decreased over the years, since those figures are now taken from the HIT database (Herkunftssicherungs- und Informationssystem für Tiere ("origin-tracing and information system for animals"); <http://www.hi-tier.de>) and thus sampling errors no longer occur. For this reason, an estimated mean value of the activity uncertainty is used in the calculation. Comparative calculations have shown that the degree of precision of these uncertainties has no impact on the total uncertainty of the greenhouse-gas inventory.

The uncertainty given for poultry relative to the emission factor for CH₄ from farm-manure management (half the 95 % confidence interval), 40 %, does not take account of the higher relevant value that applies to ducks and geese (60 %), since those groups contribute only slightly to CH₄ emissions from management of farm manure from poultry. Sample calculations have shown that the precision of the uncertainty value for all poultry is of no consequence for the greenhouse-gas inventory's total uncertainty.

With regard to the 2010 Resubmission, an error in the uncertainty of activity data for indirect N₂O emissions from leaching and surface runoff has been corrected. The correct value is 170 %, and not 300 %; cf. RÖSEMANN et al. (2011).

Table 123 shows the total uncertainty for all emissions of Sector 4, for the year 2009, along with the uncertainty for the overall trend since 1990. All emissions values are given as CO₂ equivalents; in keeping with convention, the underlying conversion factors (GWP) are 21 kg kg⁻¹ for CH₄ and 310 kg kg⁻¹ for N₂O.

As the column "Combined uncertainty as % of total national emissions" in Table 123 shows, the total uncertainty of all emissions from Sector 4 results predominantly from the uncertainties for N₂O emissions from the area of agriculturally used soils, especially the indirect emissions from leaching and surface runoff.

The modifications of calculation methods carried out with respect to the 2010 Resubmission (cf. the following chapters), especially the use of an emission factor for N₂O from leaching and surface runoff that is more than three times as high as the previous factor, lead, in comparison to the NIR 2010⁵⁹, to systematically based significant increases in the uncertainties for total emissions (75.1 % instead of 37.6 %) and trend (35.5 % instead of 24.6 %). In this regard, it is insignificant that, in the NIR 2010, uncertainties calculation still took account of CO₂ emissions, which are not reported in Sector 4.

⁵⁹ The uncertainties for total emissions and trend were not calculated for purposes of the 2010 Resubmission.

Table 123: Total-uncertainties calculation for emissions from Sector 4 (animal husbandry and use of agricultural soils)

Source category	Gas	Base year emissions, in CO ₂ equivalents	Year 2009 emissions, in CO ₂ equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Combined uncertainty as % of total national emissions in year 2009	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		(GWP _{CH4} = 21, GWP _{N2O} = 310)										
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Enteric fermentation, dairy cows	CH4	14135.1	11326.3	6	40	40.4	6.3	0.01	0.13	0.24	1.11	1.13
Enteric fermentation, other cattle	CH4	11827.2	8435.0	6	40	40.4	4.7	0.02	0.10	0.68	0.83	1.07
Enteric fermentation, pigs	CH4	601.8	577.8	10	40	41.2	0.3	0.00	0.01	0.03	0.09	0.10
Enteric fermentation, sheep	CH4	548.7	394.9	10	60	60.8	0.3	0.00	0.00	0.04	0.06	0.08
Enteric fermentation, goats	CH4	9.5	23.1	20	60	63.2	0.0	0.00	0.00	0.01	0.01	0.01
Enteric fermentation, horses	CH4	169.7	189.4	10	60	60.8	0.2	0.00	0.00	0.03	0.03	0.04
Enteric fermentation, mules, asses	CH4	1.8	1.8	100	60	116.6	0.0	0.00	0.00	0.00	0.00	0.00
Enteric fermentation, buffalo	CH4	0.0	2.4	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, dairy cows	CH4	2669.0	2573.5	6	40	40.4	1.4	0.00	0.03	0.16	0.25	0.30
Manure management, other cattle	CH4	1589.6	1046.0	6	40	40.4	0.6	0.00	0.01	0.13	0.10	0.17
Manure management, pigs	CH4	2259.8	2280.8	10	40	41.2	1.3	0.00	0.03	0.18	0.37	0.41
Manure management, sheep	CH4	15.0	10.8	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, goats	CH4	0.3	0.8	20	60	63.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, horses	CH4	26.3	29.4	10	40	41.2	0.0	0.00	0.00	0.00	0.00	0.01
Manure management, mules, asses	CH4	0.2	0.2	100	40	107.7	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, buffalo	CH4	0.0	0.2	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	CH4	57.5	86.0	20	40	44.7	0.1	0.00	0.00	0.02	0.03	0.03
Manure management, dairy cows	N2O	1159.1	961.7	6	100	100.2	1.3	0.00	0.01	0.01	0.09	0.09
Manure management, other cattle	N2O	1137.3	770.2	6	100	100.2	1.1	0.00	0.01	0.21	0.08	0.22
Manure management, pigs	N2O	360.5	366.6	10	100	100.5	0.5	0.00	0.00	0.07	0.06	0.10
Manure management, sheep	N2O	17.8	12.8	10	100	100.5	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, goats	N2O	1.1	2.7	20	100	102.0	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, horses	N2O	59.6	66.6	10	100	100.5	0.1	0.00	0.00	0.02	0.01	0.02
Manure management, mules, asses	N2O	0.7	0.7	100	100	141.4	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, buffalo	N2O	0.0	0.4	10	100	100.5	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	N2O	37.7	48.7	20	100	102.0	0.1	0.00	0.00	0.02	0.02	0.03

Source category	Gas	Base year emissions, in CO ₂ equivalents	Year 2009 emissions, in CO ₂ equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Combined uncertainty as % of total national emissions in year 2009	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		(GWP _{CH4} = 21, GWP _{N2O} = 310)										
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Soils, mineral fertilizers	N2O	12722.4	8935.0	20	80	82.5	10.1	0.02	0.10	1.59	2.91	3.32
Soils, application of manure	N2O	5613.4	4815.0	60	80	100.0	6.6	0.00	0.06	0.10	4.71	4.71
Soils, N fixing crops	N2O	855.1	478.1	50	80	94.3	0.6	0.00	0.01	0.22	0.39	0.45
Soils, crop residues	N2O	6265.2	7754.7	50	80	94.3	10.1	0.03	0.09	2.31	6.32	6.73
Soils, organic soils	N2O	5162.1	5016.2	20	200	201.0	13.9	0.01	0.06	1.59	1.64	2.28
Soils, grazing	N2O	2075.2	1580.5	40	200	204.0	4.4	0.00	0.02	0.37	1.03	1.09
Soils, indirect emissions (deposition)	N2O	2942.2	2497.9	50	400	403.1	13.9	0.00	0.03	0.15	2.04	2.04
Soils, indirect emissions (leaching, run-off)	N2O	14252.4	12247.3	170	380	416.3	70.1	0.00	0.14	1.32	33.95	33.97
Soils, sewage sludge emissions	N2O	166.9	168.4	20	80	82.5	0.2	0.00	0.00	0.03	0.05	0.06
Total		86740.2	72702.0									
Overall uncertainty (half the 95% confidence interval) (%)							75.1					35.3

6.1.7 Quality assurance and control

6.1.7.1 Review of input data and emissions results

This year, as in past years, numerous input data, and numerous errors in transfers between data sources and the tabular-form database, were reviewed. The emissions calculations were comprehensively reviewed via comparison with previous-year results, and via plausibility checks. In the same context, numerous calculation pathways and data flows were also reviewed.

The pertinent detailed report (RÖSEMANN et al., 2011, Chapter 1.3) describes methodological changes in greater detail than that applied by reports of earlier years. To support quality control, a special QC/QA matrix was created that lists the methodological changes' impacts on transparency, consistency, comparability, completeness and accuracy.

Upon completion of calculations with the GAS-EM inventory model, the relevant activity data and place-based emission factors (IEF) were entered into the CSE. Then, for control purposes, the emissions results as calculated with the CSE were compared with the emissions results obtained with the GAS-EM inventory model.

6.1.7.2 Quality System for Emissions Inventories

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. As a result of limitations of resources, it was not possible for the Single National Entity to carry out additional quality assurance.

6.1.7.3 Comparisons with the previous year's results

This year's emissions calculations were also checked via comparison with the previous year's results, in the framework of source-specific recalculations (cf. Chapters 6.2.5, 6.3.2.5 and 6.5.5).

6.1.7.4 Verification

The national emissions results calculated with the GAS-EM inventory model cannot be compared with other pertinent data from Germany, since no such data are available. Instead, the implied emission factors (IEF) and other emissions-relevant figures are compared with the relevant IPCC default values and with relevant data of other countries. That process is discussed in the following, in the relevant sub-chapters.

6.1.7.5 Reviews and reports

The agricultural section of the German emissions inventory was reviewed in 2004 by Finnish experts, in the context of a bilateral assessment process. In the main, it was judged to be complete and in conformance with proper scientific practice (LECHTENBÖHMER et al., 2005, unpublished). The in-country review carried out by UNFCCC (UNFCCC, 2005) reached the same result.

In June 2007, the German inventory was reviewed in the framework of the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention".

In September 2009, a centralized review was carried out. Its most important result was that Germany's use of the new IPCC Guidelines 2006, in source category 4.D in the agriculture sector, was not accepted.

The relevant problems were also covered by the in-country review carried out in September 2010. As a result of that review, the Resubmission 2010 was submitted; cf. Chapters 6.1 and 10.5.

The comments presented in "Synthesis & Assessment Reports" and "Reports of the individual review of the greenhouse gas inventories of Germany" were taken as the occasion to review the relevant calculation procedures specifically, and to revise them as necessary.

6.2 Enteric fermentation (4.A)

6.2.1 Source category description (4.A)

CRF 4.A					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
Enteric Fermentation, Dairy Cattle (CRF 4.A.1.a)	CH ₄	1.16 %	1.21 %	-19.9 %	
Enteric Fermentation, Non-Dairy Cattle (CRF 4.A.1.b)	CH ₄	0.97 %	0.90 %	-28.7 %	

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	NO	CS/D	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %		-40/ +60								
Distribution of uncertainties		N								
EF-determination method		CS/D/T1 /T2								

Within the source category *enteric fermentation*, the sub- source category *Dairy cows* (4.A.1.a) is a key source of CH₄ emissions in terms of level and trend; the sub- source category *Other cattle* (4.A.1.b) is a key source only in terms of level.

Microbial reactions in the animals' stomachs release CH₄. The quantities released per animal and unit of time depend on the animal species in question, on individual-animal yield and on feed composition.

Germany reports on emissions of methane (CH₄) from enteric fermentation in the stomachs of dairy cows, other cattle (calves, heifers, bulls, suckling cows, stud bulls), swine (sows, including suckling piglets weighing up to 8.5 kg per animal; weaned piglets; fattening pigs; and boars), sheep, goats, horses, mules and asses and buffalo.

The sub- source category *Dairy cows* (4.A.1.a) is the most important emissions source within the source category *enteric fermentation*. It is a key source in terms of emissions level and trend. The reasons for its status as a key source include the high animal weights involved, the high yields involved and – in keeping with the first two factors – the high gross energy intakes involved. The source category *Other cattle* (4.A.1.b) is a key source in terms of emissions level.

Table 125 in Chapter 6.2.2.4 shows all CH₄ emissions from the source category *enteric fermentation*, in the form of a time series. The factors affecting the CH₄-emissions trend include decreases in animal head counts, including decreases in the early 1990s, and

improved feed digestibility, although the latter factor has been partly offset by increases in gross energy intake, milk yield, animal weights and pregnancy rates.

CH₄ emissions from enteric fermentation, as a percentage of total CH₄ emissions from the German agricultural sector, have decreased slightly over the years (1990: 80,5 %; 2009: 77,7 %). Overall, CH₄ emissions from enteric fermentation decreased 23.2 % between 1990 and 2009.

6.2.2 Methodological issues (4.A)

6.2.2.1 Methods

In analysis of key sources in German agriculture, CH₄ emissions from dairy cows and other cattle in category 4 A, *enteric fermentation*, have been identified as key sources. For this reason, CH₄ emissions from cattle are determined via a Tier 2 method (IPCC, 1996b, 4.15 ff; IPCC, 2006, 10.24 ff). The fact that suckling calves are not ruminants was taken into account in calculations. Even though swine do not constitute a key source, the emissions pertaining to them were also calculated in accordance with the Tier 2 method. CH₄ emissions from all other relevant mammals (sheep, goats, horses, mules and asses, buffalo) were calculated via the Tier 1 method.

In principle, in both methods the emissions are calculated via the following steps:

- Identification of animal populations that are homogeneous, in terms of their properties and emissions (animal categories, sub-categories),
- Determination of the relevant activity data,
- Determination of the relevant place-based emission factors (IEF),
- Calculation of emissions as a product of a) activity number and b) emission factor.

In the simpler Tier 1 method, default emission factors are used. In the Tier 2 method, spatially and annually variable emission factors are calculated from country-specific / regionally specific and time-dependent total energy intake (cf. Chapter 6.3.4.2.1) and the pertinent methane-conversion factor (cf. Chapter 6.2.2.3), in accordance with the following formula:

Equation 4: Calculation of the CH₄ emission factor pursuant to IPCC (1996b)

$$EF_{CH_4,ent} = GE \cdot \frac{X_{CH_4,GE}}{\eta_{CH_4}}$$

where

$EF_{CH_4,ent}$	Emission factor for CH ₄ from enteric fermentation (in kg animal-place ⁻¹ a ⁻¹ CH ₄)
GE	Total energy intake (in MJ animal-place ⁻¹ a ⁻¹ GE)
$X_{CH_4,GE}$	Methane-conversion factor (in MJ MJ ⁻¹)
η_{CH_4}	Energy content of methane ($\eta_{CH_4} = 55.65 \text{ MJ (kg CH}_4\text{)}^{-1}$)

A more detailed description of the relevant procedure is provided by RÖSEMANN et al. (2011).

6.2.2.2 Changes in Methods

In the following, the calculation-methods changes made in the GAS-EM inventory model, for the present NIR 2011, are described to the extent they are relevant for calculation of CH₄ emissions from enteric fermentation.

In the dairy-cow module "excretions", the influence of grazing is now taken into account in the net energy for lactation (NEL) in raw fodder. Consequently, total energy intake (GE) decreases slightly, and thus CH₄ emissions from enteric fermentation are correspondingly lower.

In response to the in-country review 2010, as of the Resubmission 2010 the methane-conversion factor for dairy cows is no longer calculated on the basis of national data; instead, the IPCC (1996b) standard value of 6 % is used.

For fattening bulls, calculations of daily weight gains were updated with the current HIT data for 2009 (Herkunftssicherungs- und Informationssystem für Tiere (HIT; "origin-tracing and information system for animals"), <http://www.hi-tier.de>). For the period as of 1999, the HIT data are now being used for the area of fattening-bull slaughter weights. For the period through 1998, data of the Federal Statistical Office (FS 3, R. 4.2.1) are still being used. A slight increase in CH₄ emissions from enteric fermentation, per animal place, results.

For suckling cows, an error found in calculation of total energy intake (GE) has been corrected. As a result, total energy intake has increased by about 26 %, in keeping with the increase in CH₄ emissions, from enteric fermentation, per animal place.

In the equation for cumulative metabolisable energy, an error in the "fattening pigs" category had to be corrected. This has resulted in increases in metabolisable energy requirements and, thus, in total energy intake GE, in comparison with the corresponding figures in the Resubmission 2010 (3.2 % for 1990; 2.4 % for 2008).

6.2.2.3 Activity data and additional information (4.A)

With regard to animal head counts, the reader's attention is called to Chapter 6.1.4.2. The data on gross energy intake (GE) are provided in Chapter 6.1.4.3. The methane-conversion factor, averaged for all housing systems, for dairy cows, other cattle and swine is shown in the following table.

Table 124: Methane-conversion factor (4.A)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Other cattle	6.16	6.17	6.16	6.15	6.15	6.15	6.16	6.17	6.17	6.15
Swine	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Other cattle	6.15	6.16	6.15	6.15	6.16	6.14	6.15	6.15	6.14	6.15
Swine	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60

For dairy cows, the standard value of the methane-conversion factor pursuant to IPCC (1996b), Table A-1 (6 %), is used.

The value for the group of other cattle is obtained as an average, weighted with the numbers of animals in question. For calves, a conversion factor of 2 % is used, on the basis of a national expert assessment (Flachowsky, Institut für Tierernährung (Institute for animal nutrition) of the former FAL, Braunschweig) oriented to the fact that calves become ruminants only gradually; cf. Kirchgeßner (1997), p. 430 ff, for example, and Pennstate College of Agricultural Sciences (2011). Neither IPCC (1996b), which uses a figure of 6 %, nor IPCC (2006), which uses 0 %, take account of calves' gradual development into ruminants. For each of the categories suckling cows, heifers, fattening bulls and stud bulls, a methane-conversion factor of 6.5% is used, in accordance with IPCC (2006), Table 10.12. While that

value is higher than the standard value pursuant to IPCC (1996b), it provides a better representation of the circumstances prevailing in Germany, with regard to fodder quality.

The conversion factor for swine, 0.6 %, is based on IPCC (1996b), Tab. A-4.

Calculations for sheep, goats, horses, mules and asses and buffalo are carried out with Tier 1 methods for which no methane-conversion factor is required.

6.2.2.4 Calculated emissions (4.A)

The CH₄ emissions from enteric fermentation, for all German animal husbandry, are listed in Table 125.

Table 125: CH₄ emissions E_{CH₄} from animal husbandry (enteric fermentation) (4s1.A)

[Tg a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E _{CH₄}	1.30	1.17	1.15	1.14	1.14	1.14	1.14	1.11	1.10	1.09
[Tg a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E _{CH₄}	1.07	1.09	1.05	1.03	1.01	1.00	0.98	0.98	1.00	1.00

Table 126 shows, almost all CH₄ emissions from enteric fermentation in Germany result from keeping of cattle. In addition, dairy cows are the most important source category within the "cattle" group. (The emissions contributions from animals that are not listed are very low.)

Table 126: CH₄ emissions from enteric fermentation (4.A.1.a)

[Tg a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	0.67	0.61	0.60	0.60	0.60	0.60	0.60	0.59	0.57	0.57
Other cows	0.56	0.50	0.49	0.48	0.48	0.48	0.48	0.46	0.46	0.46
Swine	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Sheep	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
[Tg a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	0.56	0.56	0.55	0.55	0.54	0.54	0.52	0.53	0.54	0.54
Other cows	0.46	0.46	0.44	0.42	0.41	0.40	0.40	0.40	0.40	0.40
Swine	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Sheep	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

The emissions reduction seen since 1990 (along with increasing emission factors for dairy cows, heifers, fattening bulls, fattening pigs, sows and weaned piglets, and unchanging emission factors for all other animals) is a result of decreasing animal head counts, especially those that occurred in 1990/1991 as a result of German reunification. In later years, the decreases in animal populations are tied to increasing yields per individual animal (milk yield, weight gain). With regard to emissions trends, the impact of decreasing animal head counts is offset – at least partly – by increases in per-animal yields.

6.2.2.5 Emission factors (4.A)

Table 127 shows the chronological development of mean emission factors $IEF_{CH_4, ent}$ for dairy cows, other cattle and swine.

Table 127: CH₄ emissions from animal husbandry (enteric fermentation) (4.A.1.a)

[kg pl ⁻¹ a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	105.9	108.5	111.6	113.7	113.6	114.8	116.4	117.1	118.9	120.3
Other cows	42.9	43.7	45.0	45.4	44.8	45.2	45.4	45.3	45.6	45.9
Swine	1.06	1.09	1.09	1.10	1.10	1.11	1.12	1.13	1.14	1.13
[kg pl ⁻¹ a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	121.9	124.1	124.7	126.1	126.5	128.0	128.6	129.8	128.3	128.2
Other cows	46.1	46.2	45.8	45.8	45.7	45.7	45.9	46.2	45.8	46.0
Swine	1.14	1.14	1.14	1.14	1.15	1.15	1.15	1.15	1.16	1.17

Table 128 shows, by way of example for 2009, the emission factors for the sub-categories for other cattle:

Table 128: CH₄ emission factors (enteric fermentation) for "other cattle", for 2009, in comparison with the default values for western Europe pursuant to IPCC (1996b)-4.11, Table 4-4 and IPCC (2006)-10.29, Table 10.11

	[kg place ⁻¹ a ⁻¹ CH ₄]
Calves	4.3
Heifers	41.1
Bulls	56.3
Suckling cows	77.3
Stud bulls (mature males)	77.5
IPCC (1996) default	48
IPCC (2006) default	57

Because the calculation methods have been modified (cf. Chapter 6.2.2.1), the emission factors for dairy cows, other cattle and swine diverge from the values used in the Resubmission 2010; cf. Table 131 in Chapter 6.2.5.

For sheep, goats, large horses, mules and asses and buffalo, the default emission factors pursuant to IPCC (1996b)-4.10, Table 4-3, are used. Calculations for small horses were carried out with an emission factor that was estimated as follows: Pursuant to DLG (2005: p. 54), the average daily metabolisable-energy requirements for a small horse or pony amount to 57.5 MJ d⁻¹, or about 65% of those for a large horse (89 MJ d⁻¹). That percentage is assumed to apply as well, approximately, to the corresponding ratio of gross energy intake and, thus, to the ratio between the applicable emission factors. Table 129 shows the emission factors used for sheep, goats, large horses, small horses and ponies, mules and asses and buffalo.

Table 129: The emission factors (enteric fermentation) used in the inventory for sheep, goats, large horses, small horses and ponies, mules and asses and buffalo

Animal category	EF [kg place ⁻¹ a ⁻¹ CH ₄]
Sheep	8
Goats	5
Large horses	18
Small horses, ponies	12
Mules and asses	10
Buffalo	55

6.2.3 Uncertainties and time-series consistency (4.A)

With regard to the uncertainties in the area of methane emissions from enteric fermentation, the reader's attention is called to Table 123 in Chapter 6.1.6 (total uncertainty of the German GG inventory). All the time series are consistent.

6.2.4 Source-specific quality assurance / control and verification (4.A)

Chapter 6.1.7 provides an overview of measures relative to source-specific QA/QC and verification.

In the framework of verification, the present chapter presents a comparison between a) data from German dairy-cow husbandry in 2009, b) IPCC default values and c) data from neighbouring countries, including the UK (from 2008; UNFCCC Submission 2010). It emerges that the emission factor calculated for Germany, for dairy cows, would fit within the upper range of the corresponding data from neighbouring countries. The relevant discrepancy with the IPCC default values can be explained as a result of higher weights and higher milk yields.

Table 130: Methane emissions from enteric fermentation in dairy cows, in various countries – a comparison of Implied Emission Factors (IEF); figures for Germany for 2009; data of other countries for 2008.

	<i>IEF_{CH₄}</i>	Milk yield	Animal weight	Pregnant-cow percentage
	[kg place ⁻¹ a ⁻¹ CH ₄]	kg place ⁻¹ d ⁻¹	[kg animal ⁻¹]	[%]
Austria	115.59	16.60	700	90
Belgium	121.97	18.40	600	
Czech Republic	115.88	18.59	585	90
Denmark	130.43	23.53	575	90
Germany	128.25	18.70	642	78
France	117.33	17.23		
Netherlands	128.30			
Poland	96.57	12.29	500	84.8
Switzerland	119.98			
UK	108.94	19.12	644	
Default (IPCC, 1996b, Table 4-4, Table A-1)	100	11.5	550	90
Default (IPCC, 2006, Tables 10.11, 10A.1)	109	16.44 ¹⁾	600	90

¹⁾ calculated from 6,000 kg place⁻¹ a⁻¹

Source (except for figures for Germany): UNFCCC 2010

6.2.5 Source-specific recalculations (4.A)

In comparison to the Resubmission 2010, the following changes have resulted (cf. Table 131 and Table 132):

- As a result of methodological changes, changes appear in gross energy intake for dairy cows, fattening bulls and suckling cows (cf. Chapter 6.2.2.2), and these changes have a slight effect on calculation of the relevant emission factor.
- The methane-conversion factor for swine has increased. It now accords with the value recommended in IPCC (1996b), 0.6 %, and that value is used for all swine categories for which calculations are carried out with the GAS-EM inventory model (sows, weaned piglets, fattening pigs and boars). The corresponding value in the Resubmission 2010 was too low, since the relevant averaging took account of suckling piglets weighing up to 8.5 kg per animal, which are normally grouped with sows. The contribution from such piglets is already included in that of sows, however; cf. Chapter 6.1.4. This discrepancy is solely a matter of description, however; it does not affect the calculated emissions.

- The calculation of gross energy intake (GE) for fattening pigs has been corrected, and this has resulted in an increase in GE with respect to the Resubmission; cf. Chapter 6.2.2.2.
- All in all, total methane emissions from enteric fermentation have increased by about one percent with respect to the corresponding figure in the Resubmission 2010.

Table 131: Comparison of resulting CH₄ emission factors as reported in 2011 and in 2010 (4.A)

[kg pl ⁻¹ a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2011	105.9	108.5	111.6	113.7	113.6	114.8	116.4	117.1	118.9	120.3
Dairy cows, 2010	105.9	107.9	111.5	113.6	113.3	114.5	116.1	116.8	118.6	119.9
Other cattle, 2011	42.9	43.7	45.0	45.4	44.8	45.2	45.4	45.3	45.6	45.9
Other cattle, 2010	42.6	43.4	44.4	44.7	44.1	44.3	44.5	44.4	44.6	44.7
Swine, 2011	1.06	1.09	1.09	1.10	1.10	1.11	1.12	1.13	1.14	1.13
Swine, 2010	0.91	0.94	0.93	0.94	0.95	0.96	0.96	0.97	0.98	0.96
[kg pl ⁻¹ a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows, 2011	121.9	124.1	124.7	126.1	126.5	128.0	128.6	129.8	128.3	128.2
Dairy cows, 2010	121.6	123.7	124.3	125.7	126.1	127.5	128.2	129.3	128.0	
Other cattle, 2011	46.1	46.2	45.8	45.8	45.7	45.7	45.9	46.2	45.8	46.0
Other cattle, 2010	44.9	45.1	44.7	44.7	44.5	44.6	44.8	44.9	44.5	
Swine, 2011	1.14	1.14	1.14	1.14	1.15	1.15	1.15	1.15	1.16	1.17
Swine, 2010	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.99	

Table 132: Comparison of CH₄ emissions (enteric fermentation) as reported in 2011 and in 2010 (4.A)

[Tg a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2011	1.30	1.17	1.15	1.14	1.14	1.14	1.14	1.11	1.10	1.09
Total, 2010	1.30	1.16	1.14	1.13	1.12	1.13	1.13	1.10	1.08	1.08
Dairy cows, 2011	0.67	0.61	0.60	0.60	0.60	0.60	0.60	0.59	0.57	0.57
Dairy cows, 2010	0.61	0.60	0.60	0.60	0.60	0.60	0.59	0.57	0.57	0.61
Other cattle, 2011	0.56	0.50	0.49	0.48	0.48	0.48	0.48	0.46	0.46	0.46
Other cattle, 2010	0.56	0.50	0.48	0.47	0.47	0.47	0.47	0.45	0.45	0.45
Swine, 2011	0.029	0.025	0.025	0.025	0.024	0.023	0.024	0.024	0.026	0.026
Swine, 2010	0.028	0.025	0.025	0.024	0.023	0.023	0.023	0.024	0.026	0.025
[Tg a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total, 2011	1.07	1.09	1.05	1.03	1.01	1.00	0.98	0.98	1.00	1.00
Total, 2010	1.06	1.08	1.04	1.03	1.00	0.99	0.97	0.98	0.99	
Dairy cows, 2011	0.56	0.56	0.55	0.55	0.54	0.54	0.52	0.53	0.54	0.54
Dairy cows, 2010	0.56	0.56	0.55	0.55	0.54	0.54	0.52	0.53	0.54	
Other cattle, 2011	0.46	0.46	0.44	0.42	0.41	0.40	0.40	0.40	0.40	0.40
Other cattle, 2010	0.45	0.45	0.43	0.41	0.40	0.39	0.39	0.39	0.39	
Swine, 2011	0.025	0.025	0.026	0.026	0.025	0.027	0.026	0.027	0.027	0.028
Swine, 2010	0.025	0.025	0.025	0.026	0.025	0.026	0.026	0.027	0.026	

6.2.6 Planned improvements (4.A)

Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine

will affect data on total energy intake, which serve as a basis for calculating CH₄ emissions from enteric fermentation.

In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.

6.3 Manure management (4.B)

6.3.1 Source category description (4.B)

CRF 4.B					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
Manure Management, Dairy Cattle (CRF 4.B.1.a)	- / - / T2	CH ₄			
Manure Management, Dairy Cattle (CRF 4.B.1.a)	- / - / T2	N ₂ O			
Manure Management, Swine (CRF 4.B.8)	- / - / T2	CH ₄			

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NM VOC	SO ₂
Emission factor (EF)	NO	CS/D	NO	NO	NO	D	D	-	CS	NO
EF uncertainties in %		-40/ +60				30				
Distribution of uncertainties		N				N				
EF-determination method		D/T1/T 2				CS/T 1				

The source category *Manure management* is a key source, pursuant to Tier 2 analysis, for CH₄ and N₂O emissions from dairy cows and for CH₄ emissions (only) from swine.

Greenhouse-gas emissions from manure management include CH₄ and N₂O from storage of farm manure in stalls, from storage on paved areas outside of stalls and from dedicated storage areas (i.e. storage areas within the narrow meaning of the term). N₂O emissions as a result of grazing and manure application are reported in 4.D (Chapter 6.5).

Calculations of CH₄ and N₂O emissions from manure management must take account of a range of factors, including animal category, animal excretions (which, in turn, are a function of animal yield and of diet), the amounts of time spent by relevant animals in various defined areas (pastures, stalls, paved areas), types of stalls used, amounts of straw bedding used and the type of manure storage involved.

The source category *Manure management* is not a key source.

In 2009, a total of 22.3 % (1990: 19.5 %) of total CH₄ emissions from German agriculture were CH₄ emissions from manure management. From 1990 to 2009, such manure-management emissions decreased by about 8.9 %. That reduction is due primarily to decreases of livestock populations that occurred from 1990 through 1992, as a result of German reunification. The impacts of the reductions in livestock populations since 1990 have been partly offset by increases in total energy intake resulting from increases in per-animal yields.

In 2009, manure management accounted for a 4.9 % share of total N₂O emissions from German agriculture. The corresponding share for 1990 was 5.3 %. From 1990 through 2009,

N₂O emissions from manure management decreased by 19.6 %. That reduction, like that for CH₄ emissions, is the result of decreases in livestock populations. In this area as well, the impacts of the head-count reductions have been partly offset by yield increases (in this case, because yield increases entail increases in per-animal N excretions).

6.3.2 Methane emissions from manure management (4.B, methane)

6.3.2.1 Source category description (4.B, methane)

Cf. Chapter 6.3.1.

6.3.2.2 Methodological issues (4.B, methane)

6.3.2.2.1 Methods (4.B, methane)

For dairy cows, other cattle and swine, a Tier 2 method is used (IPCC, 1996b, p. 4.22; IPCC, 2006, p. 10.35 ff). It involves detailed calculation of VS excretions, which are proportional to intake of total energy (GE). Total energy intake is calculated as a function of yield and fodder (cf. Chapter 6.3.4.2.1). The VS excretions are calculated using maximum methane-production capacities B_o and methane-conversion factors MCF , which take account of a) the frequency of various procedures for storing solid and liquid manure, b) the frequency of grazing in Germany and c) relevant climate effects and which thus vary spatially and chronologically.

Equation 5: Calculation of VS excretions

$$EF_{CH_4, MM, i} = VS_i \cdot \alpha \cdot B_{o, i} \cdot \rho_{CH_4} \cdot \sum_{jk} MCF_{i, j, k} \cdot MS_{i, j}$$

$EF_{CH_4, MM, i}$	Emission factor for methane from manure management, for animal category i (in kg animal place ⁻¹ a ⁻¹ CH ₄)
VS_i	VS excretions of animal category i (in kg animal place ⁻¹ d ⁻¹)
α	Factor for conversion of time units ($\alpha = 365 \text{ d a}^{-1}$)
$B_{o, i}$	Maximum methane-production capacity of animal category i (in m ³ kg ⁻¹ CH ₄)
ρ_{CH_4}	Methane density ($\rho_{CH_4} = 0.67 \text{ kg m}^{-3}$)
$MCF_{i, j, k}$	Methane-conversion factor for manure-management system j and climate region k (in kg kg ⁻¹)
$MS_{i, j}$	Share of animal category i whose excrement enters into manure-management system j (in animal-place animal-place ⁻¹)

With regard to VS excretions, maximum methane-production capacity B_o and methane-conversion factors MCF , cf. Chapter 6.3.2.2.3.

This Tier 2 method is also used for laying hens, broilers, pullets and turkeys.

The same Tier 2 equation is used to calculate the emission factors for sheep, goats, horses, mules and asses, buffalo and ducks. The input figures used for those animal categories, however, are IPCC default values.

In the area of horses, a distinction is made between small horses / ponies and large horses: Pursuant to DLG (2005: p. 54), the average daily metabolisable-energy requirements for a small horse or pony amount to 57.5 MJ d⁻¹, or about 65% of those for a large horse (89 MJ d⁻¹). That percentage is assumed also to apply, approximately, to the relationship between the volatile solids (VS) excretions of small horses / ponies and those of large horses.

No data are available that would permit use of the Tier 2 method for geese. Therefore, Germany uses the Tier 1 method to calculate CH₄ emissions from manure management for that animal category.

For a more detailed description of calculation of methane emissions from farm-manure storage, the reader's attention is called to RÖSEMANN et al. (2011).

6.3.2.2.2 Methodological changes (4.B, methane)

The methodological changes mentioned in Chapter 6.2.2.2 with regard to CH₄ emissions from enteric fermentation also have an impact on CH₄ emissions from manure management.

6.3.2.2.3 Activity data and additional information (4.B, methane)

With regard to animal head counts, the reader's attention is called to Chapter 6.1.4.2. In the categories of cattle, swine and poultry (except geese), excretions of volatile solids (VS) are calculated in accordance with Tier 2 determinations of energy and substance flows. As a result of the in-country review 2010, as of the Resubmission 2010, the ash-content percentage figure needed to calculate VS excretions for dairy cows is assumed to be 8 % (IPCC, 1996b). That value supplants the previously used national figure of 13.9 %.

The VS excretions calculated with the inventory model are shown in Table 133. (The calculations for poultry did not cover geese, since it is not possible to calculate VS excretions for geese, due to the lack of a suitable description of the relevant energy intake and the lack of a pertinent IPCC default value.)

The values calculated with national data are lower than the IPCC default values (1996) for dairy cows (5.1 kg d⁻¹ VS), other cattle (2.7 kg d⁻¹ VS), swine (0.5 kg d⁻¹ VS) and poultry (0.1 kg d⁻¹ VS). With the exception of those for poultry, the IPCC default values (2006) are similar in level to the corresponding values in IPCC (1996). For poultry, IPCC (2006) lists values ranging from 0.01 kg d⁻¹ VS for broilers and 0.07 kg d⁻¹ VS for turkeys.

Table 133: Daily VS excretions per animal, for dairy cows, other cattle, swine and poultry (not including geese) (4.B(a)s1)

[kg d ⁻¹ VS]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	3.97	4.03	4.14	4.21	4.22	4.26	4.31	4.33	4.38	4.42
Other cattle	1.33	1.36	1.42	1.44	1.42	1.44	1.46	1.46	1.47	1.48
Swine	0.26	0.26	0.27	0.27	0.27	0.27	0.27	0.27	0.28	0.27
Poultry, not including geese	0.017	0.017	0.018	0.018	0.018	0.017	0.018	0.018	0.018	0.018
[kg d ⁻¹ VS]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	4.47	4.53	4.55	4.58	4.59	4.63	4.65	4.68	4.64	4.63
Other cattle	1.49	1.49	1.48	1.47	1.47	1.47	1.48	1.48	1.47	1.47
Swine	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Poultry, not including geese	0.019	0.019	0.019	0.020	0.022	0.022	0.022	0.023	0.023	0.024

For all other animals, the VS default values pursuant to IPCC (2006), Tables 10A-6 and 10A-9, were used; cf. Table 134. Those values are either in keeping with those from IPCC (1996b), p. 4.47, Table B-7, or are higher (for goats and horses). The VS excretions of small horses and ponies were derived from those of large horses, on the basis of the ratio of pertinent energy requirements (cf. Chapter 6.3.2.1):

Table 134: Daily VS excretions per animal place, for sheep, goats, horses, mules and asses, buffalo and poultry (not including geese) (4.B(a)s1)

[kg place ⁻¹ d ⁻¹]	VS
Sheep	0.40
Goats	0.30
Large horses	2.13
Small horses and ponies	1.38
Mules and asses	0.94
Buffalo	3.9
Poultry (not including geese)	0.024

Germany does not have national data on maximum rates of methane formation that could be used for calculation of CH₄ emissions from manure storage. For this reason, IPCC default values are used in this area (IPCC, 2006: 10.77 ff); cf. Table 135. Those values are either in keeping with those from IPCC (1996b), p. 4.43 ff, Table B-3 through B-7, or, with the exception of those for horses, are higher. IPCC (1996) gives a value of 0.33 m³ kg⁻¹ CH₄ for horses.

Table 135: Maximum methane-formation capacity B_0 , pursuant to IPCC (2006)-10.77ff (4.B(a)s1)

[m ³ kg ⁻¹ CH ₄]	B_0
Dairy cows	0.24
Other cattle	0.18
Swine	0.45
Sheep	0.19
Goats	0.18
Horses	0.30
Mules and asses	0.33
Buffalo	0.10

For geese, Germany uses the Tier 1 method to calculate CH₄ emissions from manure management. For that purpose, the emission factor pursuant to IPCC (1996b), Table B-7, as given for the overall "poultry" category, 0.78 kg place⁻¹ a⁻¹ CH₄, is used.

No B_0 figures are available for pullets. But since pertinent national VS figures are available, Germany uses the Tier 2 method nonetheless. For that purpose, the highest B_0 value available for poultry in IPCC (2006), Table 10A-9, is used: 0.39 m³ kg⁻¹ CH₄ (laying hens). That value is higher than the value given in IPCC (1996b), Table B-7, for poultry overall (0.32 m³ kg⁻¹ CH₄).

Also using the same procedure for geese, for poultry overall the inventory model produces the German mean B_0 values shown in the time series in Table 136. All of the values are higher than the value of 0.32 m³ kg⁻¹ CH₄ given for poultry overall in IPCC (1996b), Table B-7.

Table 136: Maximum methane-formation capacity B_0 for poultry (4.B(a)s1)

[m ³ kg ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Poultry	0.374	0.374	0.373	0.373	0.373	0.373	0.372	0.372	0.372	0.371
[m ³ kg ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Poultry	0.371	0.371	0.371	0.370	0.370	0.370	0.370	0.370	0.370	0.370

The following tables show the distribution of the various relevant types of manure-management systems (figures in % of excreted nitrogen).

Table 137: Relative shares of liquid-manure-based systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	54.8	55.2	55.3	55.1	70.8	70.8	70.9	70.9	72.2	72.3
Other cattle	59.9	60.0	58.5	57.7	56.6	55.7	55.1	54.6	54.3	53.7
Swine	80.8	80.3	80.5	81.1	87.3	87.4	87.7	87.7	89.2	89.0
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	42.0	42.0	42.0	42.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	72.3	72.4	72.3	72.4	72.4	72.4	72.3	72.5	72.7	72.7
Other cattle	53.5	53.7	53.6	53.6	53.3	53.2	53.3	53.3	53.2	53.4
Swine	89.2	89.3	89.3	89.4	89.4	89.6	89.5	89.5	89.8	90.0
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 138: Relative shares of straw--based systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	26.8	26.2	26.2	26.4	15.4	15.3	15.3	15.3	14.3	14.2
Other cattle	26.7	25.9	25.9	26.2	26.6	26.9	27.0	27.1	26.9	27.3
Swine	19.2	19.7	19.5	18.9	12.7	12.6	12.3	12.3	10.8	11.0
Sheep	28.9	30.0	29.5	28.8	28.9	29.1	28.5	28.9	29.0	27.9
Goats	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Horses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	42.0	42.0	42.0	42.0
Poultry	100	100	100	100	100	100	100	100	100	100
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	14.3	14.3	14.4	14.2	14.3	14.3	14.4	14.3	14.0	14.0
Other cattle	27.4	27.3	27.2	27.2	27.3	27.2	27.1	27.1	27.3	27.2
Swine	10.8	10.7	10.7	10.6	10.6	10.4	10.5	10.5	10.2	10.0
Sheep	28.4	28.2	28.5	27.7	28.3	28.3	28.8	28.8	28.9	28.5
Goats	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Horses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Buffalo	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Poultry	100	100	100	100	100	100	100	100	100	100

Table 139: Grazing: relative shares of housing systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	18.4	18.6	18.5	18.5	13.9	13.9	13.8	13.8	13.5	13.5
Other cattle	13.4	14.1	15.6	16.1	16.8	17.4	17.9	18.3	18.8	19.0
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	71.1	70.0	70.5	71.2	71.1	70.9	71.5	71.1	71.0	72.1
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	16.0	16.0	16.0	16.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	13.4	13.4	13.3	13.3	13.3	13.3	13.3	13.2	13.2	13.3
Other cattle	19.2	19.1	19.2	19.2	19.5	19.6	19.5	19.6	19.5	19.4
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	71.6	71.8	71.5	72.3	71.7	71.7	71.2	71.2	71.1	71.5
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Buffalo	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Germany uses the methane-conversion factors (MCF) listed in IPCC (2006), Table 10A-4 through Table 10A-9, because those factors, in contrast to those pursuant to IPCC (1996b), make it possible to differentiate the housing systems commonly used in Germany, as well as to take different temperature levels into account, as may be required in specific cases. Table 140 lists the methane-conversion factors (MCF) resulting, on an average for all liquid-manure-based systems, for dairy cows, other cattle and swine.

Table 140: Methane-conversion factors (MCF) for liquid-manure-based systems for dairy cows, other cattle and swine (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	14.0	13.9	13.9	13.8	13.4	13.4	13.4	13.4	13.4	13.4
Other cows	13.8	13.8	13.8	13.7	13.2	13.3	13.3	13.3	13.3	13.3
Swine	17.0	17.0	17.0	17.0	16.4	16.4	16.4	16.4	16.4	16.4
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
Other cows	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
Swine	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4

In keeping with IPCC (2006)-10.44, the default MCF of 2 % is used for calculations for mammals in straw-based systems, throughout the entire report period. That value is higher than the default value of 1 % given by IPCC (1996b), Table B-3 through Table B-7. For grazing, and for all years concerned, the default MCF of 1 %, as proposed by both IPCC (1996b) and IPCC (2006), is used.

For all poultry categories, an MCF of 1.5 %, in keeping with IPCC (2006)-10.82, is used. (IPCC 2006, Table 10A-9, does give an MCF value of 1 % for ducks. That value does not seem justified, however, since it is nearly impossible to keep a duck stall dry enough for it.) The MCF used in the inventory model is thus higher, for all poultry categories, than the value given by IPCC (1996b), Table B-7, for all poultry as a whole (1 %).

6.3.2.2.4 Calculated CH₄ emissions (4.B, methane)

Table 141 presents the time series for all CH₄ emissions from manure management.

Table 141: Total CH₄ emissions from manure management (4s1)

[Gg a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	315.13	282.46	279.09	276.68	293.75	291.51	294.24	290.52	296.75	294.07
[Gg a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	287.96	291.19	286.25	285.94	278.95	282.83	276.63	280.65	284.23	287.03

Table 141 shows an emissions decrease that is limited primarily to the years after German reunification and that points primarily to decreases in livestock populations. Over half of total emissions originate in keeping of cattle; keeping of swine contributes over one-third of the emissions.

Table 142 lists CH₄ emissions from manure management for dairy cows, other cattle and swine.

Table 142: CH₄ emissions from manure management for dairy cows, other cattle and swine (4.s1.)

[Gg a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	127.1	116.9	114.1	114.0	136.1	136.1	136.8	132.8	131.5	130.9
Other cattle	75.7	68.7	65.9	64.5	61.3	61.2	60.8	58.4	57.9	58.2
Swine	107.6	92.1	94.4	93.6	91.4	89.2	91.5	94.2	102.2	100.2
[Gg a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	126.8	128.3	125.4	125.0	122.7	122.2	118.2	119.1	122.8	122.5
Other cattle	57.4	58.2	54.7	53.1	50.7	50.1	49.6	49.5	49.7	49.8
Swine	98.9	99.5	101.0	102.5	100.0	105.0	103.4	106.2	105.7	108.6

6.3.2.2.5 CH₄ emission factors (4.B, methane)

Table 143 shows the chronological development of mean emission factors for CH₄ emissions from manure management for dairy cows, other cattle and swine.

Table 143: CH₄ emission factors (IEF) for manure management (4.B(a)s1)

[kg pl ⁻¹ a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	20.0	20.8	21.3	21.5	25.8	26.0	26.3	26.4	27.2	27.5
Other cattle	5.8	6.0	6.1	6.1	5.7	5.7	5.8	5.7	5.7	5.7
Swine	4.0	4.1	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.4
[kg pl ⁻¹ a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	27.7	28.2	28.3	28.6	28.6	28.9	29.0	29.2	29.1	29.1
Other cattle	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Swine	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.6	4.6

6.3.2.3 Uncertainties and time-series consistency (4.B, methane)

With regard to the uncertainties in the area of methane emissions from manure management, the reader's attention is called to Table 123 in Chapter 6.1.6 (total uncertainty of the German GG inventory). All the time series are consistent.

6.3.2.4 Source-specific quality assurance / control and verification (4.B, methane)

Chapter 6.1.7 provides an overview of measures relative to source-specific QA/QC and verification.

A comparison, carried out in the framework of verification, of a) results obtained for 2009 and b) results of neighbouring countries, and of the UK, for 2008 (submission 2010 for 2008, UNFCCC 2010) shows that Germany's CH₄ emissions from management of dairy-cow manure are approximately comparable to those of Denmark (cf. Table 144). The very high MCF values listed for liquid-manure systems in France have only a minor impact, due to the

relatively low level of use of such systems in that country. As a result, the French IEF is just under two-thirds of the corresponding German value. For a similar reason, the IEF for Poland is even lower than that for France. Because the relevant underlying detailed data are not available, it is not possible to interpret the high IEF for the Netherlands. The IEF default value given in IPCC (1996b) lies near the lower end of the scale, while the default-value range pursuant to IPCC (2006) clearly describes the prevailing circumstances more effectively.

For other cattle (cf. Table 145) and swine (cf. Table 146), Germany's emission factors lie within the range covered by the values for neighbouring countries. The high French emission factors are the result of simultaneously high VS excretions and *MCF* values; the effects of that combination are not offset by the somewhat lower use of liquid-manure systems seen in France. Internationally, the VS excretions of cattle and swine kept in Germany are at the lower end of the relevant spectrum, in terms of level.

In the poultry category (cf. Table 147), the German IEF value is similar in level to the corresponding results for Denmark and the Netherlands. The value obtained is considerably lower than the default value in IPCC (1996b); the default value in IPCC (2006) provides a better description of the situation prevailing in central Europe. For nearly all poultry categories, the German VS-excretions figures are calculated on the basis of national input data. The mean value derived from those calculated figures, for poultry, is at the lower end of the default-value range in IPCC (2006) and, thus, is considerably lower than the IPCC-1996 default value.

Table 144: Methane emissions from storage of farm manure from dairy cows, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)

	<i>IEF</i> _{CH₄}	VS excretions	Frequency of liquid-manure systems	Mean <i>MCF</i> for liquid-manure systems
	[kg place ⁻¹ a ⁻¹ CH ₄]	[kg place ⁻¹ d ⁻¹]	[%]	[%]
Austria	8.49	4.24	30.13	8.63
Belgium	16.05	3.83		19.00
Czech Republic	14.00		40.00	
Denmark	28.82	6.13	85.80	10.00
Germany	29.14	4.63	72.74	13.40
France	18.30	5.10	10.60	45/72
Netherlands	37.50			17.00
Poland	10.48	4.56	7.68	39.00
Switzerland	25.33	6.08	67.76	10.00
UK	26.76		30.60	39.00
Default (IPCC, 1996b, Table B-3)	14	5.1	40	10
Default (IPCC, 2006, Table 10.14, Table 10.17)	21 through 23 ¹	5.1	35.7	10 through 19 ¹

¹ Range for the systems and/or temperatures occurring in Germany

Source (except for figures for Germany): UNFCCC 2010

Table 145: Methane emissions from storage of farm manure from other cattle, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)

	<i>IEF_{CH4}</i>	VS excretions	Frequency of liquid-manure systems	Mean <i>MCF</i> for liquid-manure systems
	[kg place ⁻¹ a ⁻¹ CH ₄]	[kg place ⁻¹ d ⁻¹]	[%]	[%]
Austria	3.97	1.95	20.73	8.28
Belgium	2.61	1.36		19.00
Czech Republic	6.00		50.00	
Denmark	4.31	2.82	30.79	10.00
Germany	5.70	1.47	53.36	13.31
France	20.26	2.70	37.39	45 / 72
Netherlands	6.68 ¹		70.05	
Poland	4.81	2.10	11.89	39.00
Switzerland	4.87 ¹	2.01 ¹	46.94 ¹	10.00 ¹
UK	4.14	0.01	6.00	39.00
Default (IPCC, 1996b, Table B-4)	6	2.7	50	10
Default (IPCC, 2006, Table 10.14, Table 10.17)	6 through 7 ¹	2.6	25.2	10 through 19 ²

¹ calculated from original data

² Range for the systems and/or temperatures occurring in Germany

Source (except for figures for Germany): UNFCCC 2010

Table 146: Methane emissions from storage of farm manure from swine, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)

	<i>IEF_{CH4}</i>	VS excretions	Frequency of liquid-manure systems	Mean <i>MCF</i> for liquid-manure systems
	[kg place ⁻¹ a ⁻¹ CH ₄]	[kg place ⁻¹ d ⁻¹]	[%]	[%]
Austria	1.15	0.36	78.4	
Belgium	9.69	0.49		19
Czech Republic	3.00		76	
Denmark	2.02	0.22	94	10
Germany	4.63	0.28	90.0	16.4
France	20.88	0.50	82/1	45/72
Netherlands	4.43			
Poland	6.54	0.50	28.6	39
Switzerland	5.43	0.50	98.6	10
UK	7.06		31	
Default (IPCC, 1996b, Table B-6)	3	0.5	“pit>1month”:73%	10
Default (IPCC, 2006, Table 10.14, Table 10.17)	Sows. boars: 9 through 10 ¹ Other: 6	Sows. boars: 0.46 Other: 0.30	“pit>1month”: 70%	10 through 19 ¹

¹ Bereich für in Deutschland vorkommende Systeme und/oder Temperaturen

Quelle (ausgenommen Deutschland): UNFCCC 2010

Table 147: Methane emissions from storage of farm manure from poultry, in various countries – a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters (those of Germany, for 2009; those of other countries, for 2008)

	IEF_{CH₄}	VS excretions	Mean animal weight
	[kg place⁻¹a⁻¹CH₄]	[kg place⁻¹d⁻¹]	[kg animal⁻¹]
Austria	0.07	0.10	1.10
Belgium	0.04	0.03	1.60
Czech Republic	0.08		
Denmark	0.04		2.00
Germany	0.03	0.024¹	1.99
France	0.12	0.10	
Netherlands	0.03		
Poland	0.08	0.10	1.10
Switzerland	0.12	0.10	
UK	0.08		
Default(IPCC,1996b,Table B-7)	0.078	0.10	1.10
Default(IPCC, 2006-10.82)	0.02 to 0.09	0.02 to 0.07	0.9 to 6.8

¹ not including geese

Source (except for figures for Germany): UNFCCC 2010

6.3.2.5 Source-specific recalculations (4.B, methane)

Table 148 through Table 150 show the time series for the relevant shares (in percent of the excreted N) for the three different main categories of housing systems, in comparison with the data given in the Resubmission 2010. The reasons for the differences between the values reported in 2010 and those reported in 2011 are explained as follows:

- For all animals, an error was corrected in calculation of the national mean value for the relative shares of the various manure-management systems (liquid-manure-based, straw-based, grazing). That correction does not affect the emissions figures, however, since those are calculated at the district (Kreis) level.
- For horses, and for mules and asses, the figure used in the past for urine/faeces distribution between the "stall" and "grazing" categories is now no longer being used. The reason for the discontinuation is that it has not been possible to confirm the expert assessment on which that figure was based. As of the NIR 2011, as in the procedure for other animals, excretions are distributed between the "stall" and "pasture" categories in proportion to the applicable time periods spent in stalls and in pastures (cf. Chapter 6.1.3.4). That correction leads to a major shift of N excretions between the "stall" and "pasture" categories, thereby causing the resulting emission factor (IEF) to increase by up to 2 % with respect to the Resubmission 2010 (for 2008, from 2.53 to 2.58 kg pl-1 a-1 CH₄).
- Relatively large changes also result for buffalo. In this category, a calculation error in determination of the relative shares of the various manure-management systems was eliminated.

Table 148: Comparison of the relative shares of liquid-manure-based systems, as reported in 2011 and 2010, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2011	54.8	55.2	55.3	55.1	70.8	70.8	70.9	70.9	72.2	72.3
Dairy cows, 2010	54.3	54.3	55.0	55.0	70.8	70.8	70.9	70.9	70.9	72.3
Other cattle, 2011	59.9	60.0	58.5	57.7	56.6	55.7	55.1	54.6	54.3	53.7
Other cattle, 2010	58.9	57.9	58.4	57.6	56.5	55.6	54.9	54.4	54.0	53.5
Swine, 2011	80.8	80.3	80.5	81.1	87.3	87.4	87.7	87.7	89.2	89.0
Swine, 2010	80.4	79.8	80.0	80.4	86.9	87.0	87.3	87.3	87.5	89.0
Buffalo, 2011 1	NO	NO	NO	NO	NO	NO	42.0	42.0	42.0	42.0
Buffalo, 2010 1	NO	NO	NO	NO	NO	NO	38.5	38.5	38.5	38.5
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows, 2011	72.3	72.4	72.3	72.4	72.4	72.4	72.3	72.5	72.7	72.7
Dairy cows, 2010	72.3	72.4	72.4	72.5	72.5	72.5	72.5	72.5	72.5	
Other cattle, 2011	53.5	53.7	53.6	53.6	53.3	53.2	53.3	53.3	53.2	53.4
Other cattle, 2010	53.3	53.6	53.6	53.6	53.2	53.1	53.2	53.2	53.2	
Swine, 2011	89.2	89.3	89.3	89.4	89.4	89.6	89.5	89.5	89.8	90.0
Swine, 2010	89.1	89.1	89.2	89.3	89.3	89.5	89.5	89.5	89.7	
Buffalo, 2011	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Buffalo, 2010	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	

¹ Through 1995, the system included no buffalo

Table 149: Comparison of the relative shares of straw-based systems, as reported in 2011 and 2010, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2011	26.8	26.2	26.2	26.4	15.4	15.3	15.3	15.3	14.3	14.2
Dairy cows, 2010	28.2	28.2	27.3	27.3	16.1	16.1	16.0	16.0	16.0	14.9
Other cattle, 2011	26.7	25.9	25.9	26.2	26.6	26.9	27.0	27.1	26.9	27.3
Other cattle, 2010	27.7	27.9	26.0	26.3	26.7	27.0	27.2	27.3	27.4	27.5
Swine, 2011	19.2	19.7	19.5	18.9	12.7	12.6	12.3	12.3	10.8	11.0
Swine, 2010	19.6	20.2	20.0	19.6	13.1	13.0	12.7	12.7	12.5	11.0
Sheep, 2011	28.9	30.0	29.5	28.8	28.9	29.1	28.5	28.9	29.0	27.9
Sheep, 2010	28.0	28.3	28.3	28.3	28.2	28.2	28.2	28.1	28.1	27.9
Goats, 2011	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Goats, 2010	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6
Horses, 2011	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Horses, 2010	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4
Mules/asses, 2011	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses, 2010	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4
Buffalo, 2011 1	NO	NO	NO	NO	NO	NO	42.0	42.0	42.0	42.0
Buffalo, 2010 1	NO	NO	NO	NO	NO	NO	43.8	43.8	43.8	43.8
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows, 2011	14.3	14.3	14.4	14.2	14.3	14.3	14.4	14.3	14.0	14.0
Dairy cows, 2010	14.9	14.9	14.9	14.7	14.7	14.7	14.7	14.8	14.8	
Other cattle, 2011	27.4	27.3	27.2	27.2	27.3	27.2	27.1	27.1	27.3	27.2
Other cattle, 2010	27.6	27.4	27.3	27.3	27.5	27.5	27.4	27.3	27.3	
Swine, 2011	10.8	10.7	10.7	10.6	10.6	10.4	10.5	10.5	10.2	10.0
Swine, 2010	10.9	10.9	10.8	10.7	10.7	10.5	10.5	10.5	10.3	
Sheep, 2011	28.4	28.2	28.5	27.7	28.3	28.3	28.8	28.8	28.9	28.5
Sheep, 2010	28.4	28.2	28.5	27.7	28.3	28.3	28.8	28.8	28.9	
Goats, 2011	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Goats, 2010	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	
Horses, 2011	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Horses, 2010	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	
Mules/asses, 2011	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses, 2010	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	
Buffalo, 2011	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Buffalo, 2010	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	

¹ Through 1995, the system included no buffalo

Table 150: Comparison of the relative shares of for grazing, as reported in 2011 and 2010, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2011	18.4	18.6	18.5	18.5	13.9	13.9	13.8	13.8	13.5	13.5
Dairy cows, 2010	17.5	17.5	17.7	17.7	13.1	13.1	13.1	13.1	13.1	12.8
Other cattle, 2011	13.4	14.1	15.6	16.1	16.8	17.4	17.9	18.3	18.8	19.0
Other cattle, 2010	13.4	14.2	15.6	16.1	16.8	17.4	17.9	18.3	18.7	18.9
Sheep, 2011	71.1	70.0	70.5	71.2	71.1	70.9	71.5	71.1	71.0	72.1
Sheep, 2010	72.0	71.7	71.7	71.7	71.8	71.8	71.8	71.9	71.9	72.1
Goats, 2011	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Goats, 2010	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4
Horses, 2011	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Horses, 2010	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6
Mules/asses, 2011	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses, 2010	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6
Buffalo, 2011 1	NO	NO	NO	NO	NO	NO	16.0	16.0	16.0	16.0
Buffalo, 2010 1	NO	NO	NO	NO	NO	NO	17.7	17.7	17.7	17.7
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows, 2011	13.4	13.4	13.3	13.3	13.3	13.3	13.3	13.2	13.2	13.3
Dairy cows, 2010	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.7	12.7	
Other cattle, 2011	19.2	19.1	19.2	19.2	19.5	19.6	19.5	19.6	19.5	19.4
Other cattle, 2010	19.1	19.0	19.1	19.1	19.3	19.4	19.4	19.4	19.5	
Sheep, 2011	71.6	71.8	71.5	72.3	71.7	71.7	71.2	71.2	71.1	71.5
Sheep, 2010	71.6	71.8	71.5	72.3	71.7	71.7	71.2	71.2	71.1	
Goats, 2011	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Goats, 2010	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	
Horses, 2011	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Horses, 2010	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	
Mules/asses, 2011	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses, 2010	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	
Buffalo, 2011	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Buffalo, 2010	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	

¹ Through 1995, the system included no buffalo

For dairy cows, other cattle, swine and poultry, Table 151 presents a comparison of a) the VS-excretion figures calculated for the NIR 2011 and b) the corresponding values reported in the Resubmission 2010. The resulting differences are due to the following changes:

- The slight increase seen, with respect to the Resubmission 2010, in the national mean for VS excretions, amounting to less than 1 % for dairy cows and up to 3.5 % (2008) for other cattle, results from correction of an error in aggregation of data calculated at the district (Kreis) level. The correction does not affect the emissions calculations, since the national mean of VS excretions does not enter into those calculations.
- The national mean for VS excretions of swine has increased by 17 to 18 % with respect to the Resubmission 2010. The corresponding value in the Resubmission 2010 was too low, since the relevant averaging took account of suckling piglets weighing up to 8.5 kg per animal, which are normally grouped with sows. The contribution from such piglets is already included in that of sows, however; cf. Chapter 6.1.4. The correction does not affect the emissions calculations, since the national mean of VS excretions does not enter into those calculations.
- For poultry, the changes with respect to the Resubmission 2010 are due to a recent update of the model-input figure "gross meat production" for broilers, for 2007 and 2008, as well as to a model change with regard to calculation of final weight after fattening.

Table 151: Comparison of daily VS excretions per animal, as reported in 2011 and as reported in 2010, for dairy cows, other cattle and swine (4.B)

[kg d ⁻¹ VS]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2011	3.97	4.03	4.14	4.21	4.22	4.26	4.31	4.33	4.38	4.42
Dairy cows, 2010	3.95	4.01	4.12	4.18	4.20	4.23	4.28	4.30	4.36	4.39
Other cattle, 2011	1.33	1.36	1.42	1.44	1.42	1.44	1.46	1.46	1.47	1.48
Other cattle, 2010	1.32	1.35	1.39	1.41	1.39	1.41	1.42	1.42	1.43	1.44
Swine, 2011	0.26	0.26	0.27	0.27	0.27	0.27	0.27	0.27	0.28	0.27
Swine, 2010	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.23
Poultry, 2011	0.017	0.017	0.018	0.018	0.018	0.017	0.018	0.018	0.018	0.017
Poultry, 2010	0.017	0.017	0.017	0.018	0.018	0.017	0.018	0.018	0.018	0.018
[kg d ⁻¹ VS]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows, 2011	4.47	4.53	4.55	4.58	4.59	4.63	4.65	4.68	4.64	4.63
Dairy cows, 2010	4.44	4.50	4.52	4.55	4.56	4.60	4.62	4.65	4.61	
Other cattle, 2011	1.49	1.49	1.48	1.47	1.47	1.47	1.48	1.48	1.47	1.47
Other cattle, 2010	1.45	1.45	1.43	1.43	1.43	1.43	1.43	1.44	1.42	
Swine, 2011	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Swine, 2010	0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24	
Poultry, 2011	0.018	0.019	0.019	0.019	0.020	0.022	0.022	0.022	0.023	0.023
Poultry, 2010	0.018	0.019	0.019	0.020	0.021	0.022	0.022	0.022	0.022	

The changes in the VS excretions also affect the implied emission factors (IEF) and the CH₄ emissions. These effects are shown in Table 152 and Table 153, for the relevant categories, namely dairy cows, other cattle and swine.

Table 152: Comparison of CH₄ emission factors (IEF), as reported in 2011 and as reported in 2010, for manure management (4.B(a)s1)

[kg pl ⁻¹ a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2011	20.0	20.8	21.3	21.5	25.8	26.0	26.3	26.4	27.2	27.5
Dairy cows, 2010	19.9	20.6	21.1	21.3	25.7	25.9	26.2	26.3	26.6	27.3
Other cattle, 2011	5.8	6.0	6.1	6.1	5.7	5.7	5.8	5.7	5.7	5.7
Other cattle, 2010	5.7	6.0	6.1	6.1	5.7	5.7	5.7	5.7	5.7	5.7
Swine, 2011	4.0	4.1	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.4
Swine, 2010	3.4	3.5	3.5	3.5	3.6	3.7	3.7	3.7	3.8	3.8
[kg pl ⁻¹ a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows, 2011	27.7	28.2	28.3	28.6	28.6	28.9	29.0	29.2	29.1	29.1
Dairy cows, 2010	27.6	28.0	28.1	28.4	28.5	28.7	28.8	29.1	28.9	
Other cattle, 2011	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Other cattle, 2010	5.7	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.6	
Swine, 2011	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.6	4.6
Swine, 2010	3.8	3.8	3.8	3.8	3.8	3.9	3.8	3.9	3.9	

Table 153: Comparison of CH₄ emissions, as reported in 2011 and as reported in 2010, for dairy cows, other cattle and swine (4.B)

[Gg a ⁻¹ CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2011	315.1	282.5	279.1	276.7	293.7	291.5	294.2	290.5	296.8	294.1
Total, 2010	312.0	281.1	276.2	273.8	291.1	288.9	291.6	287.9	290.7	291.8
Dairy cows, 2011	127.1	116.9	114.1	114.0	136.1	136.1	136.8	132.8	131.5	130.9
Dairy cows, 2010	126.4	116.2	113.3	113.2	135.4	135.4	136.0	132.0	128.7	130.1
Other cattle, 2011	75.7	68.7	65.9	64.5	61.3	61.2	60.8	58.4	57.9	58.2
Other cattle, 2010	75.5	68.5	65.7	64.2	61.0	60.9	60.5	58.0	57.6	57.7
Swine, 2011	107.6	92.1	94.4	93.6	91.4	89.2	91.5	94.2	102.2	100.2
Swine, 2010	105.3	91.8	92.7	91.9	89.9	87.8	90.1	92.8	99.4	98.6
[Gg a ⁻¹ CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total, 2011	288.0	291.2	286.2	285.9	278.9	282.8	276.6	280.7	284.2	287.0
Total, 2010	285.9	289.2	284.2	284.0	277.1	280.9	274.7	278.6	281.5	
Dairy cows, 2011	126.8	128.3	125.4	125.0	122.7	122.2	118.2	119.1	122.8	122.5
Dairy cows, 2010	126.0	127.5	124.6	124.2	121.9	121.5	117.4	118.3	122.1	
Other cattle, 2011	57.4	58.2	54.7	53.1	50.7	50.1	49.6	49.5	49.7	49.8
Other cattle, 2010	57.1	57.8	54.3	52.8	50.4	49.8	49.2	49.1	49.2	
Swine, 2011	98.9	99.5	101.0	102.5	100.0	105.0	103.4	106.2	105.7	108.6
Swine, 2010	97.3	98.0	99.5	101.0	98.5	103.4	101.9	104.7	103.7	

6.3.2.6 Planned improvements (4.B, methane)

In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.

Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH₄ emissions from enteric fermentation.

In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.

6.3.3 NMVOC emissions from manure management (4.B, NMVOC)

6.3.3.1 Source category description (4.B, NMVOC)

The substances produced in microbial decomposition of proteins in farm manure include non-methane volatile organic compounds (NMVOCs). NMVOCs are involved in the formation of near-ground ozone.

6.3.3.2 Methodological issues (4.B, NMVOC)

6.3.3.2.1 Methods (4.B, NMVOC)

The IPCC does not provide any method for calculating NMVOC emissions from manure management. For that reason, use is made of an approach, described in EMEP (2009), that is based on the first NMVOC-emissions inventory prepared in the UK and that assumes that NH₃ emissions and NMVOC emissions are largely proportional, throughout a variety of different types of farm manure. Germany uses the relative emission factors used in that approach (HOBBS et al., 2004). As a result of the uncertainties connected with that approach, and because NMVOC emission factors are not available for all animal categories,

Germany's calculation of total NMVOC emissions from animal husbandry is only a first estimate.

For a description of the relevant procedure, cf. RÖSEMANN et al. (2011).

6.3.3.2.2 Methodological changes (4.B, NMVOC)

The methods for calculating NMVOC emissions have not been changed with respect to the Resubmission 2010. Changes in the NMVOC-emissions time series, with respect to the Resubmission 2010 (cf. Chapter 6.3.3.5), are due solely to changes in NH₃ emissions, which enter directly into calculation of NMVOC emissions.

6.3.3.2.3 Calculated NMVOC emissions (4.B, NMVOC)

Due to a lack of suitable emission factors, it was not possible to calculate NMVOC emissions for horses, mules and asses, buffalo, goats, geese, ducks and turkeys. The NMVOC-emissions time series shown in Table 154 includes NMVOC emissions for the other relevant animals. Throughout the entire report period, the relevant percentage share for cattle is on the order of 60 %, while swine contribute about one-third. Most of the remainder is contributed by those poultry species for which it was possible to calculate NMVOC emissions. The contribution from sheep is less than 1 %.

Table 154: NMVOC emissions E_{NMVOC} from animal husbandry (manure management), given as NMVOC and NMVOC-C (4s1.B, 4s2.B)

[Gg a ⁻¹ NMVOC, or Gg a ⁻¹ C]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NMVOC}	322.2	288.1	282.2	279.1	265.0	263.3	264.9	262.0	264.3	261.7
$E_{\text{NMVOC-C}}$	156.1	139.2	136.7	135.4	128.6	127.9	128.7	127.1	128.0	126.8
[Gg a ⁻¹ NMVOC, or Gg a ⁻¹ C]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E_{NMVOC}	257.4	259.7	254.1	252.9	248.4	250.1	244.4	249.3	251.0	253.9
$E_{\text{NMVOC-C}}$	124.4	125.5	122.7	122.1	119.5	120.3	117.6	119.5	120.4	121.5

Beginning in about 1994, following a decrease in animal populations, resulting from German reunification, emissions remained constant.

In the view of the auditors who conducted the in-country review of the NIR 2010, the calculation method used by Germany tends to overestimate NMVOC emissions. Since no better method is currently available (this is the reason why Denmark and Finland do not report any NMVOC emissions from sector 4.b), the pertinent overestimation cannot be quantified, however.

6.3.3.3 Uncertainties and time-series consistency (4.B, NMVOC)

The uncertainty for NMVOC emissions depends both on the uncertainty for NH₃ emissions and on the uncertainty for the emission factors EF_{NMVOC} . The first of those uncertainties is on the order of 20 % (half of the 95 % confidence interval; cf. Chapter 14.7 in RÖSEMANN et al., 2011), while a value of 30 to 50 % is assumed for the second. As a result, the uncertainty for NMVOC emissions is on the order of 50 %. A normal distribution is assumed. According to HOBBS et al. (2004), the uncertainty for NMVOC emissions from sheep manure is higher than that for NMVOC emissions from cattle and swine. For this reason, in the present report the uncertainty for the emission factors is increased by half. This leads to an emissions uncertainty of about 75 % (and that uncertainty also has a normal distribution).

6.3.3.4 Source-specific quality assurance / control and verification (4.B, NMVOC)

With regard to source-specific QA/QC and verification, the reader's attention is called to Chapter 6.1.7.

6.3.3.5 Source-specific recalculations (4.B, NMVOC)

The following changes have resulted with respect to the Resubmission 2010:

Table 155: NMVOC emissions from animal husbandry (manure management), (4s1.B, 4s2.B)

[Gg a ⁻¹ NMVOC, or Gg a ⁻¹ C]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2011	322.2	288.1	282.2	279.1	265.0	263.3	264.9	262.0	264.3	261.7
Total, 2010	300.1	269.8	264.6	262.4	252.3	250.7	252.9	249.9	252.6	250.3
[Gg a ⁻¹ NMVOC, or Gg a ⁻¹ C]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total, 2011	257.4	259.7	254.1	252.9	248.4	250.1	244.4	249.3	251.0	253.9
Total, 2010	246.4	249.0	243.9	242.3	237.7	239.7	234.3	239.0	240.1	

The values are higher throughout in comparison to the Resubmission 2010; in keeping with the calculation method used, these higher results are tied directly to higher results for NH₃ emissions. Dairy cows' share of the difference between the NMVOC total for 2011 and the NMVOC total for 2010 is about 25 %. The corresponding share for other cattle is about 35 %, while that for swine is about 37 %.

The main reason why higher NH₃-emissions results were obtained is that an error was eliminated, for all solid-manure-based housing systems, in calculation of immobilisation of TAN (with regard to TAN, cf. Chapter 6.1.3.4). In the "other cattle" category, the effects of that correction are only slightly offset by use of the lower NH₃ emission factor for grazing pursuant to EMEP(2009)-4B-26, Table 3-8, whereas for dairy cows use of the new NH₃ emission factor for grazing pursuant to EMEP(2009)-4B-26, Table 3-8, contributes to an additional increase in NH₃ emissions. For some animals, TAN concentrations and NH₃ emission factors were updated pursuant to EMEP(2009)-4B-26, Table 3-8. Such updating also led to changes in NH₃ emissions; cf. Chapter 6.3.4.2.2.

6.3.3.6 Planned improvements (4.B, NMVOC)

Because no better method is available, Germany continues to use the existing procedure for calculating NMVOC emissions from sector 4.B.

6.3.4 N₂O and NO emissions from manure management (4.B, N₂O & NO)

6.3.4.1 Source category description (4.B, N₂O & NO)

With regard to N₂O emissions, the reader's attention is called to Chapter 6.3.1.

The NO emissions calculated for the German inventory tend to behave like the N₂O emissions, since they were calculated in proportion to the N₂O emissions; cf. Chapter 6.3.4.2.5.

6.3.4.2 Methodological issues (4.B, N₂O & NO)

6.3.4.2.1 Methods (4.B, N₂O & NO)

Calculations are carried out separately for all animal categories, and taking account of the applicable manure-management systems, in accordance with the following formula:

Equation 6: Calculation of N₂O emissions from manure management

$$E_{\text{N}_2\text{O-N}} = \sum_{i,j} [(N_{\text{excr}, i} + N_{\text{straw}, i, j}) \cdot MS_{i, j}] \cdot EF_{\text{N}_2\text{O-N}, j}$$

where:

$E_{\text{N}_2\text{O-N}}$	Total N ₂ O-N emissions from manure management (kg a ⁻¹ N ₂ O-N)
$N_{\text{excr}, i}$	Total N excretions in animal category i (kg a ⁻¹ N)
$N_{\text{straw}, i, j}$	N input via straw, for animal category i and manure-management system j (kg a ⁻¹ N)
$MS_{i, j}$	Relative share of manure-management system j in animal category i (place place ⁻¹)
$EF_{\text{N}_2\text{O-N}, j}$	N ₂ O-N emission factor for manure-management system j (kg kg ⁻¹ N ₂ O-N)

For dairy cows, heifers, fattening bulls, swine, laying hens, pullets, broilers, ducks and turkey cocks and turkey hens, N excretions are calculated as a function of yield. For other animals, N-excretion data are taken from the pertinent German literature (cf. the references in RÖSEMANN et al., 2011).

The method for calculating N excretions as a function of yield is based on the fundamental assumption that feeding is in accordance with requirements: first the relevant animal energy requirements are determined, and then the figure for applicable energy content in the feed is used to determine what quantity of feed must be consumed to meet those energy requirements. (Note: That calculation also yields the total energy intake GE, which serves as the basis for calculation of CH₄ emissions from enteric fermentation (Chapter 6.2.2.1) and for calculation of VS excretions – and, thus CH₄ emissions – from manure management (Chapter 6.3.2.2.1).) The N content in the feed is used to calculate each relevant animal's N intake. That figure that then remains, following deduction of growth-related N retention, N release via products (milk/eggs) and N losses via pregnancy/young, is the N-excretions figure.

For dairy cows, N excretions are calculated as a function of milk yield, milk-protein levels, weight, number of births per year and feed composition.

For male fattening cattle and young female cattle, N excretions are calculated as a function of weight gain, final weight and feed characteristics. For calves, suckling cows and stud bulls, national data from the literature are used.

For swine, N excretions are determined from animal yields (for sows: number of piglets per year; for early weaned piglets and fattening pigs: weight gain) as well as animal weights and fodder composition.

For laying hens, pullets, broilers, ducks, turkey cocks and turkey hens, excretions are calculated as a function of weight gain, final weight and feed characteristics. For laying hens, laying yields are also taken into account.

For animal categories with grazing, calculated N excretions are broken down into in-pasture and in-stall excretions, since only in-stall excretions can enter into calculation of N₂O emissions in 4.B. The line between the two categories (excretions in stalls and excretions in

pastures) is drawn on the basis of the duration of the grazing periods, the average daily duration of grazing and, for cows, the average daily time spent in the milking stall.

NO emissions from manure management are calculated in proportion to N₂O emissions; cf. Chapter 6.3.4.2.5.

N₂O emissions from soil, resulting from excretions in pastures, are reported under 4.D.

6.3.4.2.2 Methodological changes (4.B, N₂O & NO)

In the following, the calculation-methods changes made in the GAS-EM inventory model, with respect to the Resubmission 2010, are described to the extent they are relevant for calculation of N₂O and NO emissions from manure management.

In the dairy-cow module "excretions", the influence of grazing is now taken into account in the net energy for lactation (NEL) in raw fodder. That correction leads to a reduction in N excretions of about 0.5 %. Emissions of N species are similarly reduced.

For heifers, data on age, culling age and calving rate for 2009 were added. That, in turn, slightly modified the time series resulting via linear regression. As a consequence, the N excretions for heifers at the administrative-district level are partly higher and partly lower.

For fattening bulls, calculations of daily weight gains were updated with the current HIT data for 2009 (Herkunftssicherungs- und Informationssystem für Tiere (HIT; "origin-tracing and information system for animals"), <http://www.hi-tier.de>). For the period as of 1999, the HIT data are now being used for the area of fattening-bull slaughter weights. For the period through 1998, data of the Federal Statistical Office (FS 3, R. 4.2.1) are still being used.

For suckling cows, an error found in calculation of total energy intake (GE) has been corrected. This has resulted in an increase of about 26 % in suckling cows' feed intake, thereby entailing a corresponding increase in the pertinent N excretions. (In 2009, suckling cows accounted for about 5.2 % of other cattle.)

In the equation for cumulative metabolisable energy, an error had to be corrected in the fattening-pigs category. That correction has resulted in an increase in metabolisable-energy requirements. And as a consequence of that increase, N excretions have increased with respect to the Resubmission 2010 (about 4.5 % for 1990, and about 3.3 % for 2008).

In the procedure used to date for horses, the breakdown of N excretions between the "stall" and "pasture" categories, as a result of an expert assessment, was not proportional to the time spent in pasture (cf. Haenel et al., 2010). Use of that calculation procedure, which was justified on the basis of special excretion behaviour in horses (and which was also adopted, by analogy, for mules and asses), has been discontinued in the present NIR 2011, since it was not possible to confirm the relevant expert assessment. Now, these animals' excretions are divided between the "stall" and "pasture" categories in the same manner used for excretions of other animals (cf. Chapter 6.1.3.4).

The RAUMIS data on distribution of housing systems for laying hens cover only the period through 1999; for later years, the data have simply been rolled forward. Now, those data are being supplanted by farther-reaching time series of the Federal Statistical Office that reflect a shift from cage systems to floor-pen and free-range systems that occurred especially in 2008 and 2009, as a result of legal changes. On the other hand, it is no longer possible to differentiate cage systems by types, as was previously done, since the Federal Statistical Office's data do not support such differentiation and since time-series consistency and data

reliability and currentness are seen as higher priorities. The shift from cage systems to free-range systems entails relatively higher energy requirements, and correspondingly higher feed-intake rates, as a result of the greater amounts of movement animals require to feed within such systems. Those increases entail increases in N excretions. At the administrative district level, the relevant N₂O emissions are partly higher, and partly lower, than the corresponding values calculated with the old method.

For broilers, a new approach has been implemented that builds on the existing model for calculation of fattening duration. The new approach makes it possible to take account of changes, over the years, in duration of cleaning between fattening cycles. In comparison to the results under the old model, more realistic (lower) end weights per fattening cycle result, while the numbers of fattening cycles increase. The resulting slight decrease in annual excretions per animal place is offset by correction of an error in entry of data for the applicable percentage of (heavier, and thus no longer excreting) male animals. With the aforementioned corrections, and in comparison to the Resubmission, 3.4 % higher N₂O emissions were calculated for 1990, while 4.2 % lower emissions were calculated for 2008.

For the ducks category, data on feed-utilisation efficiency and metabolisable energy in feed (ME) were updated. The resulting increase in daily ME requirements is more than offset by correction of a model error (use of duration of fattening rather than duration of the fattening cycle); as a result, the annually averaged daily ME requirements decrease by about 7 %. The newly introduced procedure for calculating N excretions supplants the previous procedure, in which higher, standard values were used. As a result, N₂O emissions have decreased.

6.3.4.2.3 Activity data and additional information (4.B(b))

With regard to animal head counts, the reader's attention is called to Chapter 6.1.4.2. The N excretions per animal place and year are given in Table 156. The total annual N excretions calculated for the various relevant manure-management systems are listed in Table 157 through Table 159.

Table 156: N excretions per animal place and year (4.B(b))

[kg place ⁻¹ a ⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	106.3	110.1	114.3	117.0	114.4	115.8	117.5	118.3	120.4	121.8
Other cattle	37.1	38.1	39.3	39.8	39.6	40.3	40.7	40.8	40.9	41.2
Swine	11.7	11.9	11.9	11.9	12.0	12.1	12.1	12.2	12.2	12.1
Sheep	7.4	7.2	7.3	7.4	7.4	7.3	7.4	7.4	7.3	7.5
Goats	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Horses	48.4	48.4	48.5	48.5	48.4	48.4	48.3	48.3	48.3	49.4
Mules/asses	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4
Buffalo, 1	NO	NO	NO	NO	NO	NO	82.0	82.0	82.0	82.0
Poultry	0.68	0.68	0.68	0.68	0.67	0.66	0.66	0.66	0.67	0.65
[kg place ⁻¹ a ⁻¹]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	123.8	126.6	127.2	128.8	129.4	131.1	131.9	133.4	131.5	131.5
Other cattle	41.4	41.3	41.0	41.0	41.0	41.0	41.0	41.1	40.8	40.8
Swine	12.1	12.1	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.1
Sheep	7.5	7.5	7.4	7.6	7.5	7.5	7.4	7.4	7.4	7.4
Goats	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Horses	49.4	49.0	49.0	49.1	49.1	49.1	49.1	49.0	49.0	49.0
Mules/asses	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4
Buffalo	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0
Poultry	0.67	0.68	0.67	0.68	0.74	0.74	0.72	0.75	0.76	0.78

¹Through 1995, the system included no buffalo

Table 157: Total annual N excretions for liquid-manure-based systems (4.B(b))

[Gg a⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	370.4	342.4	339.0	341.5	427.0	429.0	432.8	421.4	420.0	419.6
Other cattle	292.4	263.1	249.2	243.0	239.9	239.0	236.7	227.2	224.7	224.4
Swine	253.9	215.1	220.8	218.9	225.1	219.5	224.5	230.6	249.5	242.9
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo ¹	NO	NO	NO	NO	NO	NO	0.00	0.01	0.01	0.01
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a⁻¹]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	409.0	417.0	407.3	407.8	401.6	401.9	389.6	393.9	403.3	402.3
Other cattle	220.6	222.9	210.0	203.7	194.6	192.0	189.7	188.8	189.9	190.5
Swine	238.9	239.2	242.2	245.1	237.8	249.0	244.8	251.3	249.2	256.3
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

¹ Through 1995, the system included no buffalo

Table 158: Total annual N excretions for straw-based systems (4.B(b))

[Gg a⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	180.7	162.7	160.8	164.0	92.7	92.7	93.2	91.0	83.1	82.6
Other cattle	130.0	113.8	110.2	110.5	112.8	115.4	116.0	112.9	111.5	114.2
Swine	60.4	52.9	53.6	50.9	32.9	31.5	31.6	32.4	30.3	30.1
Sheep	6.9	7.0	6.4	6.4	6.1	6.4	6.3	6.1	6.1	5.7
Goats	0.65	0.62	0.65	0.67	0.69	0.72	0.76	0.83	0.90	0.98
Horses	18.9	18.9	20.5	20.5	23.0	23.0	25.0	25.0	25.0	18.7
Mules/asses	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Buffalo ¹	NO	NO	NO	NO	NO	NO	0.00	0.01	0.01	0.01
Poultry	76.9	77.3	70.7	70.5	73.6	73.0	74.0	74.6	75.8	76.4
[Gg a⁻¹]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	81.1	82.1	80.9	80.2	79.1	79.4	77.3	77.5	77.8	77.3
Other cattle	112.9	113.2	106.6	103.3	99.6	98.1	96.5	96.2	97.5	97.1
Swine	28.9	28.6	28.9	29.1	28.1	28.9	28.7	29.5	28.3	28.4
Sheep	5.8	5.9	5.8	5.7	5.7	5.6	5.4	5.4	5.2	5.0
Goats	1.01	1.16	1.16	1.16	1.16	1.23	1.30	1.30	1.37	1.59
Horses	18.7	19.7	19.7	20.5	20.5	19.5	19.5	21.1	21.1	21.1
Mules/asses	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Buffalo	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07
Poultry	78.8	82.7	81.4	84.4	90.8	89.4	87.2	95.2	96.7	99.4

¹ Through 1995, the system included no buffalo

Table 159: Total annual N excretions during grazing (4.B(b))

[Gg place ⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	124.4	115.2	113.4	114.7	83.6	84.0	84.5	82.1	78.7	78.1
Other cattle	65.3	61.8	66.5	67.9	71.1	74.7	77.1	76.2	77.7	79.3
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	17.1	16.3	15.3	15.8	15.1	15.6	15.7	15.1	15.0	14.8
Goats	0.34	0.32	0.34	0.35	0.36	0.38	0.40	0.43	0.47	0.51
Horses	4.9	4.9	5.3	5.3	5.9	5.9	6.5	6.5	6.5	4.8
Mules/asses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Buffalo ¹	NO	NO	NO	NO	NO	NO	0.00	0.00	0.00	0.01
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg place ⁻¹]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	75.6	76.9	74.8	75.0	74.0	74.1	71.7	71.8	73.5	73.5
Other cattle	79.0	79.2	75.3	72.9	71.1	70.6	69.5	69.3	69.8	69.4
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	14.6	14.9	14.5	14.8	14.5	14.2	13.5	13.3	12.7	12.5
Goats	0.53	0.60	0.60	0.60	0.60	0.64	0.68	0.68	0.72	0.83
Horses	4.8	5.1	5.1	5.3	5.3	5.0	5.0	5.5	5.5	5.5
Mules/asses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Buffalo	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

¹ Through 1995, the system included no buffalo

6.3.4.2.4 Calculated N₂O and NO emissions

The following tables show the calculated N₂O emissions from manure management, broken down by animal categories and by management systems. N₂O and NO emissions have been decreasing considerably with regard to the base year. Cattle husbandry accounts for the major part of N₂O and NO emissions (82.8 % of emitted N in 1990, and a decrease to 77.6 % in 2009).

Table 160: N₂O emissions from manure management, by animal categories (4.B)

[Gg a ⁻¹ N ₂ O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	3.739	3.389	3.352	3.398	3.408	3.418	3.443	3.358	3.283	3.279
Other cattle	3.669	3.199	3.012	2.972	3.051	3.077	3.069	2.964	2.922	2.935
Swine	1.163	1.074	1.111	1.092	1.109	1.074	1.098	1.129	1.177	1.150
Sheep	0.057	0.058	0.053	0.053	0.051	0.053	0.052	0.051	0.051	0.047
Goats	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
Horses	0.19	0.19	0.21	0.21	0.23	0.23	0.25	0.25	0.25	0.19
Mules/asses	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Buffalo ¹	NO	NO	NO	NO	NO	NO	0.0000	0.0001	0.0002	0.0002
Poultry	0.122	0.122	0.112	0.111	0.116	0.115	0.117	0.118	0.120	0.121
[Gg a ⁻¹ N ₂ O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows	3.207	3.256	3.188	3.176	3.129	3.133	3.041	3.066	3.117	3.102
Other cattle	2.883	2.895	2.734	2.652	2.545	2.513	2.473	2.456	2.487	2.484
Swine	1.121	1.120	1.129	1.147	1.107	1.164	1.145	1.181	1.163	1.183
Sheep	0.048	0.048	0.048	0.047	0.047	0.046	0.045	0.045	0.043	0.041
Goats	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.009
Horses	0.19	0.20	0.20	0.21	0.21	0.20	0.20	0.21	0.21	0.21
Mules/asses	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Buffalo	0.0004	0.0004	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009	0.0010	0.0012
Poultry	0.124	0.131	0.129	0.134	0.144	0.141	0.138	0.151	0.153	0.157

¹ Through 1995, the system included no buffalo

As the following table shows, the level of total N₂O emissions from liquid-manure-based systems in 2009 is largely similar to the corresponding level in 1990, while a marked decrease of total emissions occurred, between 1990 and 2009, in the area of solid-manure

systems (39.0 %). That decrease is due to the changes in N excretions in the relevant systems; cf. Table 158 and Table 159.

Table 161: N₂O emissions from manure management, by management systems (4.s2.B)

[Gg a ⁻¹ N ₂ O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based	4.559	4.149	4.073	4.061	4.880	4.860	4.888	4.791	4.831	4.803
Straw-based	4.388	3.890	3.780	3.779	3.095	3.118	3.151	3.090	2.984	2.926
[Gg a ⁻¹ N ₂ O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Liquid-manure-based	4.701	4.758	4.633	4.606	4.481	4.518	4.411	4.458	4.504	4.517
Straw-based	2.883	2.901	2.804	2.767	2.708	2.687	2.639	2.665	2.685	2.677

The following table lists the NO emissions calculated for manure management overall.

Table 162: NO emissions (E_{NO}) from manure management

[Gg a ⁻¹ NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NO}	1.220	1.096	1.071	1.069	1.088	1.088	1.096	1.075	1.066	1.054
[Gg a ⁻¹ NO]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E_{NO}	1.034	1.045	1.014	1.005	0.980	0.983	0.961	0.972	0.980	0.981

6.3.4.2.5 Emission factors (4.B, N₂O & NO)

Pursuant to IPCC (2000, 2006), the input data for N₂O-emissions calculation must be obtained through statistical surveys and through measurements. In the process, framework conditions such as the effectiveness of the relevant surface, the ventilation situation and the temperature for manure storage must be taken into account. The entire data-collection, data-review and documentation process is, thus, considerably involved. Since Germany does not have relevant data records available, standard values for N₂O emission factors, pursuant to IPCC (2006), p. 10.62, Table 10.21, are used. In addition to these N₂O emission factors, Table 163 also shows the factors for NO emissions and for N₂ emissions, the latter of which also have to be taken into account in the N-flow concept (cf. Chapter 6.1.3.4).

Table 163: Partial emission factors for N₂O, NO and N₂ emissions from manure storage (with regard to excreted N) (4.B(b))

Species	Farm manure	Emission factor [kg kg ⁻¹ N]
N₂O emissions	Liquid manure with floating cover	0.005
	Liquid manure without floating cover	0.000
	Liquid manure below slatted floor	0.002
	Solid manure	0.005
	Trodden manure (no turning)	0.01
	Poultry, solid manure or faeces	0.001
NO emissions	Liquid manure with floating cover	0.0005
	Liquid manure without floating cover	0.0000
	Liquid manure below slatted floor	0.0002
	Solid manure (no turning)	0.0005
	Poultry, solid manure or faeces	0.0001
N₂ emissions	Liquid manure with floating cover	0.015
	Liquid manure without floating cover	0.0000
	Liquid manure below slatted floor	0.006
	Solid manure (no turning)	0.015
	Poultry, solid manure or faeces	0.003

The emission factors for NO and N₂ were derived from the N₂O emission factors, in accordance with findings of experiments carried out in the UK (JARVIS & PAIN, 1994). The following relationship holds:

$$EF_{N_2O} = 10 EF_{NO} = 1/3 EF_{N_2}$$

6.3.4.3 Uncertainties and time-series consistency (4.B, N₂O & NO)

With regard to the uncertainties in the area of N₂O emissions from enteric fermentation, the reader's attention is called to Table 123 in Chapter 6.1.6 (total uncertainty of the German GG inventory). All the time series are consistent.

6.3.4.4 Source-specific quality assurance / control and verification (4.B, N₂O & NO)

With regard to source-specific QA/QC and verification, the reader's attention is called to Chapter 6.1.7.

A comparison carried out in the framework of verification of "implied emission factors" for N₂O emissions from Germany (current report) and neighbouring countries, including the UK (Submission 2010 for 2008, UNFCCC 2010), shows that all other countries, in general, use the N₂O-N default emission factors from IPCC (1996b), Table 4-22 (0.001 kg kg⁻¹ N for liquid manure and 0.02 kg kg⁻¹ N for solid manure; slight divergences are seen in the cases of Belgium, Denmark and the UK). Germany, on the other hand, uses the emission factors from IPCC (2006) (cf. Table 163), which provide a better description of the situation prevailing in Germany. On average, for all animal husbandry, an N₂O-N-IEF for liquid manure of 0.00339 kg kg⁻¹ N, and an IEF for solid manure of 0.00516 kg kg⁻¹ N, result for Germany. These emission factors are consistent with the median of the emission factors measured in central Europe (Freibauer 2003).

A comparison of N excretions (Table 164) with those of neighbouring countries shows that in the "dairy cows" category Germany has the third-highest N excretions, after Denmark and the Netherlands. The IPCC default values for N excretions prove to be too low for the circumstances prevailing in Germany.

In the other-cattle category, only Switzerland has considerably lower N excretions. While the IPCC (1996b) default value is considerably higher than the pertinent level prevailing in Germany (and central Europe), the excretions calculation pursuant to IPCC (2006) at least very closely approximates the German value.

The N excretions of swine as reported by Germany lie within the middle range of the corresponding data reported by neighbouring countries. The IPCC (1996b) default value is noticeably higher than the corresponding level prevailing in Germany and central Europe. A considerably better fit is seen in the excretion value calculated pursuant to IPCC (2006) default values, with mean animal weights for the subcategories (sows, weaned piglets, fattening pigs, boars).

In the poultry category, German has the second-highest N excretions, after Denmark, of all countries compared. Since the compositions of poultry populations in other countries are not reported, the comparability of the values is limited. The German value is approximately similar to the value calculated for Germany for the laying-hens category. The IPCC default value (1996b) is 0.60 kg place⁻¹ a⁻¹ and is thus too low for Germany. In addition, the excretion value calculated pursuant to IPCC (2006) default values, with mean animal weights for the relevant subcategories (pullets, laying hens, broilers, geese, ducks, turkeys), is also too low for Germany.

Table 164: N excretions per animal place, for dairy cows, other cattle, swine and poultry, in various countries (in Germany, for 2009; in other countries, for 2008)

	Dairy cows	Other cattle	Swine	Poultry
	[kg place⁻¹ a⁻¹]	[kg place⁻¹ a⁻¹]	[kg place⁻¹ a⁻¹]	[kg place⁻¹ a⁻¹]
Austria	97.03	46.54	12.71	0.55
Belgium	111.88	54.60	10.03	0.58
Czech Republic	100.00	70.00	20.00	0.60
Denmark	137.98	45.01	7.85	0.79
Germany	131.52	40.85	12.14	0.78
France	100.00	57.04	16.43	0.60
Netherlands	134.50	44.78 ¹	9.05	0.64
Poland	86.70	58.77	13.56	0.35
Switzerland	108.52	37.96 ¹	9.28	0.54
UK	111.95	48.21	10.79	0.58
Default (IPCC, 1996b, Table B-1)	100	70	20	0.6
Calculation pursuant to IPCC (2006, Table 10.19)	112.5 ²	39.6 ³	12.5 ³	0.63 ^{3,4}

Source (except for figures for Germany): UNFCCC 2010

¹ calculated from original data

² calculated for German mean animal weight in 2009, cf. Table 118

³ calculated with German mean animal weights for subcategories, for 2009

⁴ Assumption: the corresponding value for turkey can be used as a substitute for the lacking IPCC-2006 default-excretion rate for geese

6.3.4.5 Source-specific recalculations (4.B, N₂O & NO)

Table 165 shows the N excretions per animal place, as calculated for the NIR 2011, in comparison to the corresponding values in the Resubmission 2010. The resulting differences are explained as follows:

- Throughout the entire report period, somewhat lower N excretions were calculated for dairy cows (1990: about - 0.4 %; 2008: about - 0.8 %). The reason for this is that grazing was taken into account in calculation of the mean net energy for lactation (NEL) in raw fodder.
- For other cattle, daily weight gains were updated for fattening bulls, and this has led to a slight increase in N excretions. For heifers, data on age, culling age and calving rate for 2009 were added. This slightly modified the relevant time series resulting via linear regression. As a result, for heifers, slightly higher N excretions resulted in some years and slightly lower N excretions resulted in others. These changes have affected the total result for mean place-oriented N excretions of other cattle, with respect to the Resubmission 2010.
- The N excretions for swine are about 18 % higher, throughout the entire report period. This is the result of correction of an error in the energy calculation for fattening pigs.
- For poultry, slight changes in N excretions result, especially as of the year 2000. The reasons for this include the shift in housing systems, taken into account for laying hens as of the present inventory, from cage systems to free-range systems; the latter entail relatively higher energy requirements and correspondingly higher feed-ingestion rates, due to the higher amounts of movement hens require for feeding in free-range systems. In addition, a shortening of cleaning cycles as of 2000 has been taken into account for broilers. This has led to higher throughput figures and, in turn, to lower final weights from fattening, given constant meat production per place and year. Because maintenance-energy requirements depend non-linearly on animal weight, for the years as of 2000 this leads to a (slight) decrease in feed intake and, thus, in N excretions, per place and year. This reduction is offset by correction of a data-entry error in the applicable percentage of (heavier – and thus no longer excreting –) male animals.

Table 165: Comparison of N excretions per animal place as reported in 2011 and as reported in 2010 (4.B)

[kg place ⁻¹ a ⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2011	106.3	110.1	114.3	117.0	114.4	115.8	117.5	118.3	120.4	121.8
Dairy cows, 2010	106.7	110.9	115.4	118.1	115.1	116.6	118.4	119.2	121.4	122.7
Other cattle, 2011	37.1	38.1	39.3	39.8	39.6	40.3	40.7	40.8	40.9	41.2
Other cattle, 2010	37.1	38.1	39.2	39.7	39.6	40.2	40.7	40.8	41.0	41.2
Swine, 2011	11.7	11.9	11.9	11.9	12.0	12.1	12.1	12.2	12.2	12.1
Swine, 2010	9.9	10.1	10.1	10.1	10.2	10.3	10.3	10.4	10.4	10.2
Poultry, 2011	0.68	0.68	0.68	0.68	0.67	0.66	0.66	0.66	0.67	0.65
Poultry, 2010	0.68	0.68	0.69	0.68	0.67	0.66	0.66	0.67	0.68	0.65
[kg place ⁻¹ a ⁻¹]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cows, 2011	123.8	126.6	127.2	128.8	129.4	131.1	131.9	133.4	131.5	131.5
Dairy cows, 2010	124.7	127.5	128.1	129.7	130.4	131.9	132.7	134.2	132.5	
Other cattle, 2011	41.4	41.3	41.0	41.0	41.0	41.0	41.0	41.1	40.8	40.8
Other cattle, 2010	41.4	41.3	41.0	41.0	41.1	41.1	41.1	41.2	40.8	
Swine, 2011	12.1	12.1	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.1
Swine, 2010	10.2	10.2	10.2	10.2	10.1	10.1	10.1	10.1	10.2	
Poultry, 2011	0.67	0.68	0.67	0.68	0.74	0.74	0.72	0.75	0.76	0.78
Poultry, 2010	0.67	0.70	0.67	0.67	0.74	0.75	0.74	0.77	0.77	

As a result of these changes in N excretions per animal place – changes in which, due to the differences in relevant animal head counts, the reduction for cattle more than offsets the increase for swine – the total N excretions for all animals are lower as calculated for the NIR 2011 than as calculated for the Resubmission 2010; cf. Table 166.

Table 166: Comparison of total N excretions of all animals, as calculated in 2011 and as calculated in 2010 (in Gg a⁻¹)

[kg place ⁻¹ a ⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nex, total for 2011	1603.5	1452.5	1432.8	1431.1	1410.1	1411.1	1425.3	1402.7	1405.6	1393.4
Nex, total for 2010	1633.9	1474.4	1456.5	1447.9	1433.2	1425.1	1447.1	1416.3	1412.4	1422.0
[kg place ⁻¹ a ⁻¹]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nex, total for 2011	1370.7	1389.5	1354.5	1349.7	1324.9	1329.9	1300.7	1321.2	1333.1	1341.1
Nex, total for 2010	1389.9	1417.0	1373.5	1361.1	1344.2	1340.0	1307.0	1333.9	1345.2	

Table 168 shows a comparison of N₂O emissions, as reported for 2011 and for 2010, from manure management, for both liquid-manure-based and straw-based systems. With respect to the Resubmission 2010, the emissions from liquid-manure-based systems are slightly increased, for all years in the report period. For straw-based systems, a slight increase for the years 1990 through 1997, with respect to the Resubmission 2010, gives way to a decrease for the years as of 1998. The reasons for this include:

- The differences in N excretions per animal place; cf. Table 165,
- The changes, as described in Chapter 6.3.2.5, in the percentage breakdown for the various relevant housing systems, and
- The discrepancies between the animal head counts as reported in the NIR 2011 and the corresponding data in the Resubmission 2010 (cf. Chapter 6.1.4.2.), which discrepancies influence the absolute figures for N₂O emissions.

Table 167: Comparison of N₂O emissions from manure management, as reported in 2011 and as reported in 2010, by systems (4.s2.)

[Gg a ⁻¹ N ₂ O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based, 2011	4.559	4.149	4.073	4.061	4.880	4.860	4.888	4.791	4.831	4.803
Liquid-manure-based, 2010	4.545	4.148	4.070	4.059	4.873	4.856	4.885	4.788	4.773	4.798
Straw-based, 2011	4.388	3.890	3.780	3.779	3.095	3.118	3.151	3.090	2.984	2.926
Straw-based, 2010	4.352	3.853	3.751	3.749	3.059	3.081	3.113	3.052	3.033	2.989
[Gg a ⁻¹ N ₂ O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Liquid-manure-based, 2011	4.701	4.758	4.633	4.606	4.481	4.518	4.411	4.458	4.504	4.517
Liquid-manure-based, 2010	4.698	4.755	4.630	4.604	4.479	4.513	4.404	4.449	4.493	
Straw-based, 2011	2.883	2.901	2.804	2.767	2.708	2.687	2.639	2.665	2.685	2.677
Straw-based, 2010	2.946	2.975	2.875	2.839	2.784	2.761	2.713	2.743	2.757	

The NO emissions have changed, with respect to the Resubmission 2010, in the same manner that the N₂O emissions have changed, since both emissions types come from the same N pool and since the NO emission factors are directly proportional to the N₂O emission factors (cf. Chapter 6.3.4.2.5). In sum, the NO emissions, with respect to the Resubmission 2010, are higher for the period through 1998, and subsequently lower for the following years through 2008. The following table shows the relevant changes in the total NO emissions:

Table 168: Comparison of NO emissions (E_{NO}) from manure management, as reported in 2011 and as reported in 2010

[Gg a ⁻¹ NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E _{NO} 2011	1.220	1.096	1.071	1.069	1.088	1.088	1.096	1.075	1.066	1.054
E _{NO} 2010	1.213	1.091	1.066	1.065	1.082	1.082	1.091	1.069	1.065	1.062
[Gg a ⁻¹ NO]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E _{NO} 2011	1.034	1.045	1.014	1.005	0.980	0.983	0.961	0.972	0.980	0.981
E _{NO} 2010	1.042	1.054	1.023	1.015	0.990	0.992	0.971	0.981	0.989	

6.3.4.6 Planned improvements (4.B, N₂O & NO)

With regard to planned improvements, the reader's attention is called to Chapter 6.3.2.6. The improvement in modelling of feeding of swine is expected to also influence the results for N₂O emissions from manure management.

6.4 Rice cultivation (4.C)

No rice is cultivated in Germany (NO).

6.5 Agricultural soils (4.D)

6.5.1 Source category description (4.D)

CRF 4.D										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend					
Agricultural Soil, Direct Soil Emissions		l / t / T2	N ₂ O	2.52 %	2.89 %	-11.8 %				
Agricultural Soil, Indirect Emissions		l / - / T2	N ₂ O	1.41 %	1.57 %	-14.2 %				

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	IE	NO	NO	NO	NO	C/D	C/D	NO	C	NO
EF uncertainties in %						-80/ +400				
Distribution of uncertainties						L				
EF-determination method						C/D/T 1/T2				

Microbial transformations of N compounds (nitrification and denitrification) lead to emissions of N₂O.

With regard to *direct and indirect N₂O emissions*, the source category *Agricultural soils* is a key source in terms of emissions level. With regard to *direct emissions*, it is also a key source in terms of trend.

From 1990 to 2009, N₂O emissions from soils decreased by 13.1 %. Their share of total N₂O emissions from German agriculture has remained nearly constant throughout the same period (1990: 94.7 %; 2009: 95.1 %).

6.5.2 Methodological issues (4.D)

6.5.2.1.1 Basic concept

In the method used to calculate N₂O emissions from soils, it is assumed that transformation of N compounds, via nitrification and denitrification, is proportional to the N added to the soil anthropogenically. That quantity of nitrogen also includes N fractions from application of manure and from grazing. Those fractions are calculated with the help of the N-flow concept; cf. Chapter 6.1.3.4.

A detailed description of calculation of N₂O emissions from agricultural soils is presented by RÖSEMANN et al. (2011). The following chapters present the most important aspects of such calculation, including the pertinent changes with respect to the Resubmission 2010.

6.5.2.1.2 Direct N₂O emissions from agricultural soils (4.Ds1.2, 4.Ds1.3)

Direct N₂O emissions from application of mineral fertilisers are calculated, via a Tier 1 method pursuant to IPCC (1996b)-4.92 ff, as a proportion of the N quantity that remains from the N quantity in applied fertiliser after deduction of N losses via NH₃ and NO emissions. In the German inventory, the remaining N quantity is calculated not with the help of the value $Frac_{GASF}$ but with values for explicitly calculated NH₃ and NO emissions. (With regard to $Frac_{GASF}$, cf. Chapter 6.5.2.1.7.) For the activity data, data on sales of mineral fertilisers, as recorded statistically at the Land (state) level, are used, instead of figures for quantities of mineral fertiliser applied, which quantities are unknown. Pursuant to IPCC(1996b)-4.89, Table 4-18, the emission factor is set at $EF_{fert, N_2O} = 0.0125 \text{ kg kg}^{-1} \text{ N}_2\text{O-N}$. In the Resubmission 2010, that emission factor was applied, erroneously, to the N quantity in applied mineral fertiliser, causing the calculation to yield overly high N₂O emissions.

Calculation of direct N₂O emissions as a result of application of farm fertiliser is carried out analogously to calculation of such emissions from application of mineral fertiliser. Consequently, the relevant emission factor is set at $EF_{man, N_2O} = 0.0125 \text{ kg kg}^{-1} \text{ N}_2\text{O-N}$. In the Resubmission 2010, that emission factor was applied, erroneously, to the N quantity in applied farm fertiliser, causing the calculation to yield overly high N₂O emissions. With regard to determination of the relevant activity data, cf. Chapter 6.1.3.4.

In previous reporting (up to, and including, the Resubmission 2010), it was assumed that German exports of farm fertiliser can be neglected, that all relevant imports come from the Netherlands and that such imports can be treated, for the purposes of this context, as poultry faeces. More recently, more precise analysis of the relevant available data has revealed that the database for identification of German net imports of farm fertiliser is inadequate. For the time being, therefore, no effort will be made to take account of imports and exports in calculation of emissions from application of farm fertiliser. For details, cf. RÖSEMANN et al. (2011).

Direct N₂O emissions from N excretions during grazing are calculated in accordance with IPCC (1996b). For a given animal, the applicable quantity of N excretions on pasture is a function of the animal's total excretions and time spent on pasture. For all animal categories, the emission factor $EF_{graz, N_2O} = 0.02 \text{ kg kg}^{-1} \text{ N}_2\text{O-N}$ is applied to the quantity of N excreted.

IPCC (1996b), pg. 4.89, recommends that emissions from use of sewage sludges not be calculated. IPCC (2000), on the other hand, proposes that sewage sludges be treated like mineral and farm fertiliser. For this reason, sewage sludges are taken into account in the area of direct N₂O emissions, in keeping with IPCC (2006)-11.7. For each Land (state) in Germany, the N quantities that enter into agricultural systems via sewage sludges are taken from data of the Federal Environment Agency and (since 2009) of the Federal Statistical Office. While other types of N emissions from use of mineral fertiliser are calculated, no other N emissions from sewage sludges are calculated; as a result, the N quantities tied to sewage sludges are used directly as activity data. In keeping with the procedure used for application of mineral fertiliser, the relevant emission factor is set at $EF_{man, N_2O} = 0.0125 \text{ kg kg}^{-1} \text{ N}_2\text{O-N}$.

Direct N₂O emissions from cultivation of organic soils are calculated in proportion to the applicable area. The applicable area data are obtained from data used to prepare inventories of emissions from land use and land-use changes. In particular, in the present case, the area data for the years 1990 through 2005, as reported in the Resubmission 2010 – which data, due to a lack of more differentiated data – were treated as constants, have been replaced

with chronologically differentiated data; cf. Chapter 6.5.2.2, Table 171. The data for the years 2006 through 2008 have also been updated. Pursuant to IPCC (2000), Table 4.17, an emission factor of $8 \text{ kg ha}^{-1} \text{ a}^{-1} \text{ N}_2\text{O-N}$ is used.

Direct N_2O emissions from biological N fixing are calculated in proportion to the quantity of bound N. For each crop, that quantity is determined as the product of the cultivated area and the specific fixing rate. The relevant data for the cultivated areas are provided by the Federal Statistical Office, while the fixing data are obtained from FAUSTZAHLEN (1993), p. 477, and from Saxony's state institute for agriculture (Sächsische Landesanstalt für Landwirtschaft; SLL, 2005, p. 86). In keeping with the procedure used for application of mineral fertiliser, the relevant emission factor is set at $EF_{\text{fix, N}_2\text{O}} = 0.0125 \text{ kg kg}^{-1} \text{ N}_2\text{O-N}$.

Direct N_2O emissions from crop residues are calculated as a proportion of the N quantities remaining in the soil (IPCC, 2006, 11.13). Those quantities result from the applicable figures for cultivated areas, yields and crop-specific N content. The data for cultivated areas and yields are reported by the Federal Statistical Office. For the first time, data of the Federal Statistical Office (StatBA FS3 R3) on yields from meadows, mowed pastures and field-fodder cultivation are being used; those data supplant the pertinent (higher) expert assessments used in the past. The data on relative N content found in crop residues are taken from a list of the Institute of Vegetable and Ornamental Crops (IGZ; 2007) and from the Fertiliser Ordinance (Düngeverordnung (DVO), 1996). The N quantities removed from relevant areas as straw for straw bedding are deducted. In keeping with the procedure used for application of mineral fertiliser, the relevant emission factor is set at $EF_{\text{fix, N}_2\text{O}} = 0.0125 \text{ kg kg}^{-1} \text{ N}_2\text{O-N}$.

6.5.2.1.3 *Indirect N_2O emissions from agricultural soils, as a result of deposition of reactive nitrogen (4.Ds1.3)*

Indirect N_2O emissions from agricultural soils include a) N_2O emissions from deposition of previously emitted, reactive nitrogen and b) N_2O emissions from surface runoff and leaching.

The German procedure for calculating deposition-related N_2O emissions, as described below, is in line with the meaning of the Tier 1 procedure in IPCC (2006: 11.21). The equation for that procedure, 11.9 (IPCC, 2006: 11.21) is not used by Germany, however, since that equation does not take account of $\text{NH}_3\text{-N}$ and NO-N emissions from straw bedding, legume cultivation and crop residues. Since, furthermore, that equation is not consistent with the definition of $Frac_{\text{GASM}}$ in CRF Table 4.Ds2 (cf. Chapter 6.5.2.1.7), it can be used only as an approximation in checking of calculated German N_2O emissions (cf. Chapter 6.5.2.3).

The German inventory calculates the deposition-related N_2O emissions as the product of the $\text{N}_2\text{O-N}$ conversion factor, 44/28, the emission factor ($0.01 \text{ kg kg}^{-1} \text{ N}$, IPCC, 1996, Table 4-23) and the sum of the N content of the following NH_3 and NO emissions, which are described further below:

- NH_3 emissions from use of mineral fertilisers
- NO emissions from use of mineral fertilisers
- NH_3 emissions from farm-manure management, including application
- NO emissions from farm-manure management, including NO as a result of application of farm manure
- NH_3 emissions from grazing
- NO emissions from grazing
- NH_3 emissions from legume cultivation

- NO emissions from legume cultivation
- NO emissions from crop residues

NH₃ and NO emissions from use of mineral fertiliser are calculated as a proportion of the N quantity applied. The NH₃ emission factors for the various fertiliser types are calculated, pursuant to EMEP(2009)-4D-Table 3-2, as a function of spring temperatures. Those temperature data are based on regionally differentiated figures of Deutscher Wetterdienst (the German meteorological service). The NO emission factor is given in Chapter 6.5.2.1.5.

NH₃ and NO emissions from manure management also include emissions resulting from application. NH₃ emissions are calculated separately for the categories stall, storage and application. The N quantity found at the beginning of the stall-storage-application chain also includes the nitrogen introduced with straw bedding (cf. Chapter 6.1.3.4). Differentiated NH₃ emission factors are available for the stalling, storage and application procedures commonly used in Germany (cf. RÖSEMANN et al., 2011). NO emissions are a) combined for the stall and storage categories and b) calculated as a consequence of application of farm manure. The NO emission factor for the stall-storage areas is set at 10 % of the relevant N₂O emission factor (cf. RÖSEMANN et al., 2011); the emission factor for NO as a result of application is given in Chapter 6.5.2.1.5.

NH₃ and NO emissions from excretions during grazing are calculated in proportion to the N quantity excreted. The NH₃ emission factors are differentiated by type of animal; cf. EMEP (2009)-4B-26. The NO emission factor is given in Chapter 6.5.2.1.5.

NH₃ and NO emissions from legume cultivation are calculated in proportion to the N quantity fixed (with regard to calculation of the N quantity fixed, cf. Chapter 6.5.2.1.2). Pursuant to EMEP(2007)-B1020-12, the NH₃ emission factor is set at $EF_{\text{fix, NH}_3} = 0.01 \text{ kg kg}^{-1} \text{ NH}_3\text{-N}$; the NO emission factor is given in Chapter 6.5.2.1.5.

NO emissions from crop residues are calculated in proportion to the N quantities remaining in the soil (with regard to calculation of these N quantities, cf. Chapter 6.5.2.1.2). The NO emission factor is given in Chapter 6.5.2.1.5. (As a result of inclusion of new data on yields from meadows, mowed pastures and field-fodder cultivation, the NO emissions from crop residues are lower; cf. Chapter 6.5.2.1.2)

6.5.2.1.4 Indirect N₂O emissions from agricultural soils, as a result of leaching and surface runoff (4.Ds1.3)

The indirect N₂O emissions from leaching and surface runoff are obtained, via a simple Tier 1 method pursuant to IPCC(1996b), p. 4.109, as the products of the N₂O-N conversion factor, 44/28, the activity figure, the fraction of the soil N quantity affected by leaching and surface runoff ($Frac_{\text{LEACH}}$; cf. Chapter 6.5.2.1.8) and the relevant emission factor (0.025 kg kg⁻¹ N, IPCC, 1996b, Table 4-23). That emission factor has been used as of the Resubmission 2010. It is more than three times as large as the emission factor previously used in German reporting, pursuant to IPCC (2006), 0.0075 kg kg⁻¹ N; cf. the relevant backward-projection chapter, 10.5.2.11.

The activity level is obtained as the sum of the sub-activity levels given below (with respect to the relevant NH₃ and NO emissions, the reader's attention is called to Chapter 6.5.2.1.3; with respect to direct N₂O emissions, the reader's attention is called to Chapter 6.5.2.1.2; N₂ emissions are calculated via a procedure similar to that used for direct N₂O emissions; the relevant emission factor is set at 0.1 kg kg⁻¹ N – cf. RÖSEMANN et al., 2011).

The sub- activity levels for application of mineral fertiliser and farm fertiliser, and for grazing, consist of the N quantities spread or excreted in each case, less the N losses from NH₃ emissions and from direct N₂O, NO and N₂ emissions.

The sub- activity level from application of sewage sludge consists of the relevant N quantity applied, less the N losses via direct N₂O emissions. (No NH₃, NO and N₂ emissions are calculated.)

The sub- activity level for biological N fixing is taken to be the N quantity fixed (with regard to calculation of the N quantity fixed, cf. Chapter 6.5.2.1.2), less the N losses via NH₃ emissions and direct N₂O, NO and N₂ emissions.

For crop residues, the sub- activity level is obtained as the applicable N content (with regard to calculation of these N quantities, cf. Chapter 6.5.2.1.2), less the N losses via direct N₂O, NO and N₂ emissions. (No NH₃ emissions are calculated).

6.5.2.1.5 NO emissions

The procedure for calculating NO emissions is described in Chapter 6.5.2.1.3. The following table shows the emission factors used.

Table 169: Emission factors EF_{NO} für NO emissions from agricultural soils

	EF_{NO} kg kg ⁻¹ NO-N]	Remark
Application of mineral fertiliser	0.012	STEHFEST & BOUWMAN (2006)
Application of farm fertiliser	0.012	STEHFEST & BOUWMAN (2006)
Grazing	0.02	Assumption: $EF_{NO} = EF_{N_2O}$ (EMEP, 2003, B1020-11,12)
N fixing (legumes)	0.012	Similar to that for application of fertiliser
Crop residues	0.007	EMEP (2003), B1020-12

6.5.2.1.6 NMVOC emissions from agricultural soils and crops

The IPCC does not provide any method for calculating NMVOC emissions from agricultural soils and crops. Levels of NMVOC emissions from plants were thus estimated using the procedure set forth in EMEP (2009). At present, NMVOC can be calculated solely for crop cultivation and grassland. The emission factors used for that purpose are taken from KÖNIG et. al. (1995). The activity value used is the crop-cultivation and grassland area.

6.5.2.1.7 $Frac_{GASF}$ and $Frac_{GASM}$

$Frac_{GASF}$ is calculated in accordance with the definition in CRF-4.Ds2.

The definition of $Frac_{GASM}$ given in CRF-4.Ds2 ("Fraction of livestock N excretion that volatilizes as NH₃ and NO_x") is in keeping with the definition implied by Equation 9 in IPCC (1996b)-4.112. This becomes apparent when Equation 9 in IPCC (1996b)-4.112 is reformulated in terms of $Frac_{GASM}$:

Equation 7: Derivation of $Frac_{GASM}$ from Equation 9 in IPCC (1996b)-4.112

$$Frac_{GASM, Eq. 9} = \frac{E_{N_2O} / EF_4 - N_{fert} \cdot Frac_{GASF}}{N_{ex}}$$

where

$Frac_{GASM, Eq. 9}$ $Frac_{GASM}$ value from Equation 9 in IPCC (1996b)-4.112 (in Gg Gg⁻¹)

E_{N_2O} / EF_4	Total emissions of N_2O -N from agricultural soils, via deposition of reactive nitrogen from emissions of NH_3 -N and NO -N (in Gg a ⁻¹ N_2O -N)
$N_{fert} \cdot Frac_{GASF}$	Emissions of N_2O -N via deposition of reactive nitrogen from emissions of NH_3 -N and NO -N from application of mineral fertiliser (in Gg a ⁻¹ N_2O -N)
N_{ex}	Total national N quantity from animal excretions (in Gg a ⁻¹ N)

This definition does not take account of NH_3 and NO emissions from straw bedding, while the German inventory does take account of straw bedding. The N quantity input via straw bedding, and the resulting emissions, are covered by the N-flow concept used by Germany, however (cf. Chapter 6.1.3.4). To ensure the consistency of Germany's inventory results, they thus have to be taken into account in the definition of $Frac_{GASM}$. These considerations lead to the definition of the value as reported by Germany, $Frac_{GASM, Germany}$:

Equation 8: Definition of the value $Frac_{GASM, Germany}$

$$Frac_{GASM, Germany} = \frac{E_{NH_3-N, MM} + E_{NH_3-N, grazing} + E_{NO-N, storage} + E_{NO-N, application} + E_{NO-N, grazing}}{m_{excr} + m_{straw}}$$

where

$Frac_{GASM, Germany}$	Nitrogen fraction from animal excrement and straw bedding (straw) that is emitted as NH_3 -N and NO -N (in Gg Gg ⁻¹)
$E_{NH_3-N, MM}$	Emissions of NH_3 -N from manure management (in Gg a ⁻¹ NH_3 -N)
$E_{NH_3-N, grazing}$	Emissions of NH_3 -N from grazing (in Gg a ⁻¹ NH_3 -N)
$E_{NO-N, storage}$	Emissions of NO -N from manure storage (in Gg a ⁻¹ NO -N)
$E_{NO-N, application}$	Emissions of NO -N from manure application (in Gg a ⁻¹ NO -N)
$E_{NO-N, grazing}$	Emissions of NO -N as a result of N excretions during grazing (in Gg a ⁻¹ NO -N)
m_{excr}	N quantity excreted in animal husbandry (including grazing) (in Gg a ⁻¹ N)
m_{straw}	N quantity introduced in animal husbandry via straw bedding (straw) (in Gg a ⁻¹ N)

Because the relevant input data vary over time, $Frac_{GASM, Germany}$ is not a constant.

As a result of the aforementioned differences between the $Frac_{GASM}$ definitions, it is not possible to conform the indirect N_2O emissions (CRF-4.Ds1.3.1) as reported in the German inventory by inserting $Frac_{GASM, Germany}$ into Equation 9 from IPCC (1996b)-4.112; cf. Chapter 6.5.2.3 in this regard.

6.5.2.1.8 The other *Frac* figures

$Frac_{BURN}$ is not reported (NO), since field burning of crop residues is prohibited in Germany.

$Frac_{FUEL}$ is not reported (NO), since use of animal excrement as fuel is of no significance in Germany.

In keeping with the definition in CRF-4.Ds2, $Frac_{GRAZ}$ is calculated as the ratio of N excreted during grazing to total N excretions.

For $Frac_{LEACH}$, the German inventory, in keeping with IPCC (1996b), p. 4.106, uses a constant value of 0.30 kg kg⁻¹ N.

$Frac_{NCRBF}$ describes the N fraction in dry matter of N-fixing plants, without taking harvest products into account. It is calculated as a weighted average of the contributions of field peas, broad beans, yellow lupins, clover, clover-containing mixtures, alfalfa, garden peas, bush beans and runner beans.

$Frac_{NCR0}$ describes the N fraction in dry matter of non-N-fixing plants, without taking harvest products into account. It is determined as a weighted average for grain, rape, sugar and fodder beets, potatoes, grass and vegetables (not including peas and beans).

In accordance with the definition in CRF-4.Ds2, $Frac_R / Frac_{Remove}$ are calculated as a fraction of the above-ground biomass that is removed as part of the harvest. That fraction can be usefully determined for those crops that form above-ground fruit. In the German inventory, it is calculated for grain, rape, peas, beans, lupins and grasses. Root crops and vegetables are not taken into account (the latter is not included for reasons of inadequate data). The straw quantities that are used for straw bedding are also not considered as harvest products.

6.5.2.2 Activity data and additional information (4.D)

The following tables present activity data and additional information that serve as a basis for calculation of direct and indirect N₂O emissions from the area of agricultural soils.

The following table shows the activity data for calculation of direct N₂O emissions. (With regard to determination of these activity data, cf. Chapter 6.5.2.1.2.)

Table 170: N quantities on which calculation of direct N₂O emissions is based (4.Ds1.1.1 through 4.Ds1.1.4)

[Gg a ⁻¹ N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral fertiliser	2089.3	1943.3	1863.1	1744.9	1552.9	1720.8	1702.7	1689.9	1718.2	1827.7
Farm manure	921.9	829.5	815.6	813.6	830.3	828.8	836.4	823.2	825.6	817.9
Grazing	213.0	199.4	201.7	204.8	176.7	181.2	184.8	181.0	178.8	178.1
Sewage sludges	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
N fixing, legumes	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
Crop residues	1028.9	981.8	899.4	1012.1	904.7	956.9	1017.8	1055.4	1047.6	1052.7
[Gg a ⁻¹ N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mineral fertiliser	1935.9	1768.3	1713.9	1710.8	1747.6	1704.1	1705.6	1525.9	1728.8	1467.3
Farm manure	805.3	816.7	797.0	794.6	778.7	783.0	766.4	779.2	786.2	790.7
Grazing	175.2	177.3	170.8	169.1	166.0	165.0	160.9	161.0	162.7	162.2
Sewage sludges	33.0	29.9	28.2	29.3	28.3	27.4	27.0	26.0	27.7	27.7
N fixing, legumes	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	78.5
Crop residues	1036.9	1060.6	1011.8	889.8	1133.3	1101.8	1024.7	1147.4	1220.6	1273.5

Table 171: Area of cultivated organic soils, in the NIR 2011 and in the Resubmission 2010, on which calculation of direct N₂O emissions is based (4.Ds1.1.5)

[1,000 ha]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Org. soils, 2011	1325	1324	1323	1322	1321	1320	1320	1319	1318	1317
Org. soils, 2010	1303	1303	1303	1303	1303	1303	1303	1303	1303	1303
[1,000 ha]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Org. soils, 2011	1316	1314	1311	1309	1306	1303	1298	1293	1286	1287
Org. soils, 2010	1303	1303	1303	1303	1303	1303	1297	1289	1285	

The NH₃ and NO emissions on which calculation of indirect N₂O emissions from deposition of reactive nitrogen is based are summarised in Table 172. The quantity of reactive nitrogen on which calculation of N₂O emissions is based is obtained via multiplication by 14/17, for NH₃, and by 14/30, for NO; cf. Table 173.

Table 172: Sums, as calculated for the inventory, of NH₃ and NO emissions from German agriculture that serve as a basis for calculation of deposition-related indirect N₂O emissions

[Gg a ⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E _{NH3}	668.1	602.2	587.3	587.0	562.5	567.0	571.8	565.8	569.5	567.2
E _{NO}	115.2	106.0	101.7	100.6	92.9	98.4	99.3	99.1	99.9	102.4
[Gg a ⁻¹]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E _{NH3}	560.8	570.9	558.9	557.0	552.6	547.6	541.7	548.4	555.0	569.3
E _{NO}	104.2	100.9	97.7	95.5	99.4	97.8	96.0	93.3	99.9	94.2

Table 173: Reactive nitrogen N_{reac} upon which calculation of N₂O emissions is based (4.Ds1.3.1)

[Gg a ⁻¹ N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N _{reac}	604.0	545.4	531.1	530.3	506.6	512.9	517.3	512.2	515.6	514.9

[Gg a-1N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N _{leach}	510.5	517.3	505.8	503.3	501.5	496.6	490.9	495.1	503.7	512.8

Table 174: Leached-out quantity of N (including surface runoff) (4.Ds1.3.2)

[Gg a-1N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N _{leach}	1170.5	1081.5	1030.7	1030.5	948.9	1011.4	1026.4	1030.3	1037.3	1063.6
[Gg a-1N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N _{leach}	1081.4	1047.4	1011.5	977.2	1045.0	1026.5	1000.5	985.7	1060.1	1006.1

For the relevant fraction quantities (*Frac* quantities; cf. Chapters 6.5.2.1.7 and 6.5.2.1.8), the time series presented in the following tables were calculated for the German inventory. With regard to the definition of *Frac*_{GASM, Germany}, cf. Chapter 6.5.2.1.7. The quantities *Frac*_{BURN} and *Frac*_{FUEL} are of no relevance for the German inventory (NO). The value of *Frac*_{LEACH} remains a constant 0.3 throughout the entire period covered by the report.

Table 175: *Frac*_{GASF} (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<i>Frac</i> _{GASF}	0.034	0.034	0.033	0.036	0.037	0.037	0.038	0.038	0.039	0.039
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Frac</i> _{GASF}	0.039	0.043	0.043	0.043	0.044	0.042	0.044	0.046	0.043	0.054

Table 176: *Frac*_{GASM, Germany} (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<i>Frac</i> _{GASM, Germany}	0.314	0.313	0.311	0.309	0.303	0.302	0.302	0.302	0.303	0.302
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Frac</i> _{GASM, Germany}	0.301	0.301	0.302	0.302	0.303	0.303	0.303	0.304	0.304	0.305

Table 177: *Frac*_{GRAZ} (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<i>Frac</i> _{GRAZ}	0.132	0.137	0.140	0.143	0.125	0.128	0.129	0.129	0.127	0.127
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Frac</i> _{GRAZ}	0.127	0.127	0.126	0.125	0.125	0.124	0.123	0.122	0.122	0.121

Table 178: *Frac*_{NCRBF} (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<i>Frac</i> _{NCRBF}	0.0481	0.0490	0.0475	0.0473	0.0469	0.0450	0.0438	0.0430	0.0417	0.0406
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Frac</i> _{NCRBF}	0.0417	0.0395	0.0402	0.0373	0.0395	0.0417	0.0424	0.0441	0.0437	0.0429

Table 179: *Frac*_{NCR0} (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<i>Frac</i> _{NCR0}	0.0235	0.0229	0.0237	0.0236	0.0238	0.0232	0.0228	0.0222	0.0226	0.0222
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Frac</i> _{NCR0}	0.0224	0.0216	0.0225	0.0210	0.0210	0.0217	0.0215	0.0219	0.0204	0.0203

Table 180: *Frac*_R (*Frac*_{Remove}) (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<i>Frac</i> _R	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.56	0.57	0.56
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Frac</i> _R	0.57	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.55

6.5.2.3 Calculated emissions from the area of agricultural soils (4.D)

he results of the relevant N₂O- and NO-emissions calculations are presented in Table 181.

Table 181: N₂O and NO emissions E_{N_2O} and E_{NO} from agricultural soils (4s1, 4s2)

$[Gg\ a^{-1}\ N_2O],$ $[Gg\ a^{-1}\ NO]$	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N_2O}	161.5	150.3	144.3	144.3	134.3	141.5	143.3	143.6	144.5	147.4
E_{NO}	114.0	104.9	100.7	99.5	91.8	97.3	98.2	98.0	98.8	101.4
$[Gg\ a^{-1}\ N_2O],$ $[Gg\ a^{-1}\ NO]$	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E_{N_2O}	149.3	145.6	141.2	137.2	144.8	142.6	139.4	137.8	146.2	140.3
E_{NO}	103.2	99.9	96.6	94.5	98.5	96.8	95.0	92.3	98.9	93.2

As Table 181 clearly shows, N₂O emissions decreased from 1990 to 1992. Thereafter, N₂O and NO emissions varied around a mean of 142.6 Gg a⁻¹ N₂O, with a minimum of 134.3 Gg a⁻¹ N₂O (1994) and a maximum of 149.3 Gg a⁻¹ N₂O (2000). For 2009, a share of 20.5 % of N₂O emissions from soils can be allocated to use of mineral fertilisers in the soil; 17.8 % can be allocated to crop residues; 11.1 % can be allocated to application of farm manure; 11.5 % can be allocated to cultivation of organic soils; and 28.2 % can be allocated to indirect emissions as a result of leaching and surface runoff. The remaining emissions consist of emissions from grazing, sewage sludge, legumes and indirect emissions from deposition of reactive N species. The time series for N₂O emissions from the various relevant sub-sources are shown in Table 187.

Table 182 shows the indirect N₂O emissions resulting from deposition of reactive N species, as calculated for the German inventory using the method described in Chapter 6.5.2.1.3, i.e. a method whereby, in contrast to the procedure in (1996b)-4.112, NH₃ and NO emissions from litter (straw bedding) used in animal husbandry are also taken into account.

Table 182: Indirect N₂O emissions resulting from deposition of reactive N species, as calculated for the NIR 2011

$[Gg\ a^{-1}\ N_2O]$	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	9.49	8.57	8.35	8.33	7.96	8.06	8.13	8.05	8.10	8.09
$[Gg\ a^{-1}\ N_2O]$	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	8.02	8.13	7.95	7.91	7.88	7.80	7.71	7.78	7.91	8.06

Table 183 shows estimates of (non-methane) volatile organic compounds from plant residues.

Table 183: NMVOC emissions from crop cultivation and grassland (4s1.D, 4s2.D)

$[Gg\ a^{-1}\ NMVOC]$	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	1.34	1.70	1.68	1.69	1.70	1.70	1.54	1.64	1.76	1.93
$[Gg\ a^{-1}\ NMVOC]$	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	1.84	1.91	2.07	2.00	2.06	2.13	2.22	2.35	2.19	2.29

6.5.2.4 Implied emission factors (IEF) (4.D)

No implied emission factor (IEF) can be calculated for total N₂O emissions from the area of agricultural soils, because the various relevant N₂O sub-emissions involved are tied to different types of activity data.

With regard to the emission factors that must be assigned to the relevant sub-emissions, we refer to Chapter 6.5.2. An international comparison is presented in Chapter 6.5.3.

6.5.3 Source-specific quality assurance / control and verification (4.D)

With regard to source-specific QA/QC and verification, the reader's attention is called to Chapter 6.1.7.

For purposes of verification, the following table compares the N₂O emission factors used for the present NIR 2011 with the corresponding figures, from last year, of neighbouring countries, including the UK (UNFCCC 2010). With the exception of the Netherlands (and Denmark, for organic soils), all of the countries listed use the default emission factors of the IPCC(1996b).

Table 184: Comparison of the N₂O emission factors used in the German inventory with those of neighbouring countries (those of Germany, for reference year 2009; those of other countries, for 2008)

[kg kg ⁻¹ N ₂ O-N]	<i>EF</i> _{N₂O} , min fert	<i>EF</i> _{N₂O} , manure	<i>EF</i> _{N₂O} , legumes	<i>EF</i> _{N₂O} , crop residues	<i>EF</i> _{N₂O} , histosols *	<i>EF</i> _{N₂O} , grazing	<i>EF</i> _{N₂O} , deposition	<i>EF</i> _{N₂O} , leaching
Austria	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.0100	0.0250
Belgium	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0250
Czech Republic	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.0100	0.0250
Denmark	0.0125	0.0125	0.0125	0.0125	3.01	0.0200	0.0100	0.0250
Germany	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0250
France	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.0100	0.0250
Netherlands	0.0099	0.0200	0.0100	0.0100	4.70	0.0165	0.0098	0.0243
Poland	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0251
Switzerland	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0250
UK	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0250

* Units: kg ha⁻¹ N₂O

Source (except for figures for Germany): UNFCCC 2009, Table 4.Ds1

Table 185 compares the fractions *Frac*_{GASF}, *Frac*_{GASM}, *Frac*_{GRAZ}, *Frac*_{LEACH}, *Frac*_{NCR0}, *Frac*_{NCRBF} and *Frac*_{Remove}, as determined for Germany, with the corresponding results of countries that either are neighbouring countries or have agricultural practices that are comparable to those of Germany.

The spread seen in the case of *Frac*_{GASF} can be explained as the result of differences in urea fractions. That possibility cannot be comprehensively assessed, however, since the distribution of fertiliser quantities among individual crops is not known.

Table 185: Comparison of the *Frac* values used in the German inventory with those of neighbouring countries (those of Germany, for 2009; those of other countries, for 2008)

[kg kg ⁻¹]	<i>Frac</i> _{GASF}	<i>Frac</i> _{GASM}	<i>Frac</i> _{GRAZ}	<i>Frac</i> _{LEACH}	<i>Frac</i> _{NCR0}	<i>Frac</i> _{NCRBF}	<i>Frac</i> _{Remove}
Austria	0.035	0.27	0.058	0.30	0.009	0.026	0.34
Belgium	0.033	0.21	0.31	0.14	0.015	0.030	0.49
Czech Republic	0.100	0.20	0.20	0.30	0.020	0.030	0.45
Denmark	0.018	0.19	0.09	0.33	0.017	0.039	0.73
Germany	0.054	0.305¹⁾	0.121	0.30	0.020	0.043	0.552
France	0.100	0.20	0.41	0.30		0.03	
Netherlands	0.035	0.176	0.174	0.30			
Poland	0.100	0.20	0.06	0.30	0.014	0.027	0.44
Switzerland	0.045	0.32	0.19	0.20	0.015	0.023	0.71
UK	0.100 ²⁾	0.20 ²⁾	0.52 ²⁾	0.30 ²⁾	0.015 ²⁾	0.03 ²⁾	0.45 ²⁾
IPCC(1996b)-4.94							
IPCC(2006)-11.24	0.100	0.20		0.30	0.015	0.03	0.45

¹⁾ *Frac*_{GASM}, Germany pursuant to Chapter 6.5.2.2

²⁾ reported in submission 2009, CRF Table4.Ds2

Source (except for figures for Germany): UNFCCC 2010, Table 4.Ds1

6.5.4 *Uncertainties and time-series consistency (4.D)*

With regard to the uncertainties in the area of N₂O emissions from agricultural soils, the reader's attention is called to Table 123 in Chapter 6.1.6 (total uncertainty of the German GG inventory).

In keeping with EMEP(2003)-B1010-26, an uncertainty factor of 10 is used for NO emissions from use of mineral fertilisers and farm manure.

According to EMEP (2003)-1020-15, the uncertainty factor for NO emissions from grazing could well be 5 or higher. That figure has been adopted for NO emissions from crop residues, since no special uncertainty data are available for that area.

EMEP(2003)-B1020-27 gives a factor of 30 for the uncertainty of NMVOC emissions. In light of the relatively low estimate for the uncertainty of the activity data (< 5 %), that uncertainty is determined primarily by the uncertainty of the emission factors. Consequently, the uncertainty for the emission factors, like that for the emissions themselves, may be assumed to be on the order of 30.

The calculated time series are consistent.

6.5.5 *Source-specific recalculations (4.D)*

In comparison to the Resubmission 2010, the following main changes have resulted (cf. also Table 186):

- In the NIR 2011, the N quantities from mineral-fertiliser application upon which the N₂O calculation is based are lower, throughout, than the corresponding figures reported in the Resubmission 2010. The reason for this is that the relevant calculation procedure has since been corrected; it now again is in line with the procedure in IPCC (1996b); cf. Chapter 6.5.2.1.2.
- The situation is similar for the N quantities from application of farm fertiliser; cf. Chapter 6.5.2.1.2. In addition, an error in calculation of TAN immobilisation in stalls has been corrected for all housing systems involving solid manure. That correction has led to a noticeable increase in NH₃ emissions from storage, with the result that less N is available for application. Furthermore, the relevant quantity of animal N excretions is somewhat lower overall, and this has also had an effect (cf. Chapter 6.3.4.5).
- In the NIR 2011, the N quantities from grazing upon which the N₂O calculation is based are lower, throughout, than the corresponding figures reported in the Resubmission 2010. This is due to a reduction in N excretions (cf. also Chapter 6.3.4.5 in this regard).
- The N quantities from crop residues upon which the N₂O calculation is based are also lower, throughout, in the NIR 2011 than the corresponding figures reported in the Resubmission 2010. This is the result of changes in the database for yields from meadows, mowed pastures and field-fodder cultivation; cf. Chapter 6.5.2.1.2.
- The quantity of emitted reactive nitrogen that was reported in the Resubmission 2010 incorporated a units-conversion error in the applicable fraction from crop residues. Correction of that error has led to higher values for reactive nitrogen, overall, in the NIR 2011.

- In the NIR 2011, the N losses from the soil resulting from leaching and surface runoff are lower, for all years of the time series, than the relevant values in the Resubmission 2010. This is due to revision of the relevant calculation method; the method now correctly takes account of previous N losses via emissions of N species; cf. Chapter 6.5.2.1.4.
- In the area of sewage sludge, the data reported for 2010 and for 2011 differ only with respect to the year 2008. This is the result of updating of the sewage-sludge quantity entered for 2008.

The data for emissions from biological N fixing have not changed, as Table 186 and Table 187 show.

Table 186: Comparison of N quantities, as reported in 2010 and as reported in 2011, used to calculate N₂O emissions from agricultural soils (4.D)

[Gg a ⁻¹ N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral fertilisers, 2011	2089.3	1943.3	1863.1	1744.9	1552.9	1720.8	1702.7	1689.9	1718.2	1827.7
Mineral fertilisers, 2010	2163.6	2011.5	1927.2	1810.1	1612.0	1787.3	1769.1	1757.1	1787.2	1901.9
Manure, 2011	935.9	842.2	828.1	826.0	842.8	841.3	849.0	835.6	838.0	830.2
Manure, 2010	1187.1	1073.9	1052.5	1048.1	1059.9	1058.9	1064.1	1044.0	1046.1	1047.0
Grazing, 2011	212.1	198.6	200.9	204.1	176.1	180.6	184.2	180.4	178.3	177.6
Grazing, 2010	216.2	198.9	203.9	205.6	178.7	181.4	185.8	181.5	180.0	182.7
Crop residues, 2011	1028.9	981.8	899.4	1012.1	904.7	956.9	1017.8	1055.4	1047.6	1052.7
Crop residues, 2010	1085.6	1034.5	948.6	1046.5	943.6	992.7	1055.3	1090.6	1078.5	1080.5
N fixing, 2011	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
N fixing, 2010	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
Indirect, deposition 2011	604.0	545.4	531.1	530.3	506.6	512.9	517.3	512.2	515.6	514.9
Indirect, deposition 2010	573.1	519.7	506.2	506.5	492.8	500.2	502.7	497.0	501.5	507.1
Indirect, leaching, 2011	1170.5	1081.5	1030.7	1030.5	948.9	1011.4	1026.4	1030.3	1037.3	1063.6
Indirect, leaching, 2010	1286.3	1187.5	1133.6	1128.1	1047.8	1108.8	1123.7	1124.4	1130.7	1158.4
Sewage sludge, 2011	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
Sewage sludge, 2010	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
[Gg a ⁻¹ N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mineral fertilisers, 2011	1935.9	1768.3	1713.9	1710.8	1747.6	1704.1	1705.6	1525.9	1728.8	1467.3
Mineral fertilisers, 2010	2013.6	1847.0	1791.7	1787.8	1827.8	1778.4	1783.7	1599.8	1807.2	
Manure, 2011	817.4	828.9	808.9	806.5	790.4	794.7	777.8	790.8	798.0	802.5
Manure, 2010	1032.3	1050.4	1024.3	1015.3	999.9	1002.7	981.2	997.4	1005.4	
Grazing, 2011	174.7	176.8	170.4	168.6	165.5	164.5	160.5	160.6	162.3	161.8
Grazing, 2010	179.3	182.4	175.3	174.2	170.6	168.1	163.9	164.9	166.7	
Crop residues, 2011	1036.9	1060.6	1011.8	889.8	1133.3	1101.8	1024.7	1147.4	1220.6	1273.5
Crop residues, 2010	1059.9	1082.6	1032.3	934.7	1158.7	1129.0	1064.2	1177.0	1256.5	
N fixing, 2011	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	78.5
N fixing, 2010	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	
Indirect, deposition 2011	510.5	517.3	505.8	503.3	501.5	496.6	490.9	495.1	503.7	512.8
Indirect, deposition 2010	503.8	512.6	501.9	498.0	497.4	491.8	488.1	491.0	498.5	
Indirect, leaching, 2011	1081.4	1047.4	1011.5	977.2	1045.0	1026.5	1000.5	985.7	1060.1	1006.1
Indirect, leaching, 2010	1173.8	1141.9	1103.2	1073.3	1135.5	1117.5	1092.3	1076.7	1152.6	
Sewage sludge, 2011	33.0	29.9	28.2	29.3	28.3	27.4	27.0	26.0	27.7	27.7
Sewage sludge, 2010	33.0	29.9	28.2	29.3	28.3	27.4	27.0	26.0	26.0	

All in all, as a result of the modifications listed above, and described in chapters 6.2.2 and 6.3.4.2, the N₂O emissions are lower than as reported in the Resubmission 2010, as Table 187 shows.

Table 187: Comparison of N₂O emissions from agricultural soils as reported in 2010 and as reported in 2011 (4.D)

[Gg a ⁻¹ N ₂ O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
EN₂₀ total, 2011	161.5	150.3	144.3	144.3	134.3	141.5	143.3	143.6	144.5	147.4
EN₂₀ total, 2010	173.2	160.9	154.7	154.1	144.3	151.5	153.3	153.3	154.1	157.5
Mineral fertilisers, 2011	41.0	38.2	36.6	34.3	30.5	33.8	33.4	33.2	33.7	35.9
Mineral fertilisers, 2010	42.5	39.5	37.9	35.6	31.7	35.1	34.7	34.5	35.1	37.4
Manure, 2011	18.1	16.3	16.0	16.0	16.3	16.3	16.4	16.2	16.2	16.1
Manure, 2010	23.3	21.1	20.7	20.6	20.8	20.8	20.9	20.5	20.5	20.6
Grazing, 2011	6.7	6.3	6.3	6.4	5.6	5.7	5.8	5.7	5.6	5.6
Grazing, 2010	6.8	6.4	6.4	6.5	5.7	5.8	5.9	5.8	5.8	5.8
Crop residues, 2011	20.2	19.3	17.7	19.9	17.8	18.8	20.0	20.7	20.6	20.7
Crop residues, 2010	21.3	20.3	18.6	20.6	18.5	19.5	20.7	21.4	21.2	21.2
Organic soils, 2011	16.7	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
Organic soils, 2010	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
N fixing, 2011	2.8	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.3	2.1
N fixing, 2010	2.8	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.3	2.1
Indirect, deposition 2011	9.5	8.6	8.3	8.3	8.0	8.1	8.1	8.0	8.1	8.1
Indirect, deposition 2010	9.0	8.2	8.0	8.0	7.7	7.9	7.9	7.8	7.9	8.0
Indirect, leaching, 2011	46.0	42.5	40.5	40.5	37.3	39.7	40.3	40.5	40.7	41.8
Indirect, leaching, 2010	50.5	46.7	44.5	44.3	41.2	43.6	44.1	44.2	44.4	45.5
Sewage sludge, 2011	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.6	0.6
Sewage sludge, 2010	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.6	0.6
[Gg a ⁻¹ N ₂ O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EN₂₀ total, 2011	149.3	145.6	141.2	137.2	144.8	142.6	139.4	137.8	146.2	140.3
EN₂₀ total, 2010	159.2	155.8	151.2	147.7	154.8	152.5	149.6	147.7	156.5	
Mineral fertilisers, 2011	38.0	34.7	33.7	33.6	34.3	33.5	33.5	30.0	34.0	28.8
Mineral fertilisers, 2010	39.6	36.3	35.2	35.1	35.9	34.9	35.0	31.4	35.5	
Manure, 2011	15.8	16.0	15.7	15.6	15.3	15.4	15.1	15.3	15.4	15.5
Manure, 2010	20.3	20.6	20.1	19.9	19.6	19.7	19.3	19.6	19.7	
Grazing, 2011	5.5	5.6	5.4	5.3	5.2	5.2	5.1	5.1	5.1	5.1
Grazing, 2010	5.7	5.8	5.6	5.5	5.5	5.4	5.3	5.3	5.4	
Crop residues, 2011	20.4	20.8	19.9	17.5	22.3	21.6	20.1	22.5	24.0	25.0
Crop residues, 2010	20.8	21.3	20.3	18.4	22.8	22.2	20.9	23.1	24.7	
Organic soils, 2011	16.5	16.5	16.5	16.5	16.4	16.4	16.3	16.3	16.2	16.2
Organic soils, 2010	16.4	16.4	16.4	16.4	16.4	16.4	16.3	16.2	16.2	
N fixing, 2011	1.9	2.0	1.9	1.9	1.8	1.9	1.8	1.6	1.5	1.5
N fixing, 2010	1.9	2.0	1.9	1.9	1.8	1.9	1.8	1.6	1.5	
Indirect, deposition 2011	8.0	8.1	7.9	7.9	7.9	7.8	7.7	7.8	7.9	8.1
Indirect, deposition 2010	7.9	8.1	7.9	7.8	7.8	7.7	7.7	7.7	7.8	
Indirect, leaching, 2011	42.5	41.1	39.7	38.4	41.0	40.3	39.3	38.7	41.6	39.5
Indirect, leaching, 2010	46.1	44.9	43.3	42.2	44.6	43.9	42.9	42.3	45.3	
Sewage sludge, 2011	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Sewage sludge, 2010	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	

6.5.6 Planned improvements (4.D)

In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.

In March 2011, the Federal Statistical Office plans to carry out a special survey of data relative to application of farm manure. The results of that survey will have an impact on the NH₃ and NO emissions of relevance for indirect N₂O emissions.

Currently, efforts to improve modelling of feeding of swine are underway. In addition, the Federal Statistical Office plans to conduct a survey of protein inputs in swine fattening. The model changes are also expected to affect the results for NH₃ emissions from farm-manure management, which are of relevance with regard to indirect N₂O emissions from agricultural soils. In co-operation with the Federal Statistical Office, efforts are being made to produce a reliable estimate of Germany's net imports of farm manure.

In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which

work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.

6.6 Prescribed burning of savannas (clearance of land by prescribed burning) (4.E)

Land clearance by prescribed burning is not practiced in Germany (NO).

6.7 Field burning of agricultural residues (4.F)

Burning of agricultural residues is prohibited in Germany. It is not possible to collect data on permitted exceptions. Such exceptions are considered to be irrelevant (NO).

7 LAND USE, LAND USE CHANGES AND FORESTRY (CRF SECTOR 5)

7.1 Overview (CRF Sector 5)

For the present submission, reporting on CRF Sector 5 has been fundamentally changed with respect to the previous years. This system change was needed because the previous procedures led to inconsistencies in designation of land-use and land-use-change areas, as well as to inconsistencies in the relevant time series. Furthermore, the previous procedure led to inconsistencies between KP-LULUCF reporting and UNFCCC reporting, thereby keeping reporting in both frameworks from conforming fully to applicable rules. With a view to eliminating these inconsistencies, a pertinent action plan (cf. Chapter 19.5.2.7) has been submitted to the FCCC Secretariat. The system changes made, as of the present report, in the LULUCF / KP – LULUCF sector are part of the implementation of that plan.

For this reason, for the present LULUCF inventory a mixed approach is being used, for the first time, for designation of land use and land-use changes in Germany; this approach links the results of the sampling inventory for the forest sector (BWI, cf. Chapter 7.2) with those of the GIS-controlled "wall-to-wall" approach for areas outside of forested areas (chapters 7.3 – 7.7). This approach was needed in the interest of ensuring spatial and chronological consistency between reporting in the Kyoto Protocol framework and reporting in the UNFCCC framework. Consequently, in area designations for all categories that have to do with forest (the categories of "forest land remaining forest land" and conversions to and from forest), the National Forest Inventory has served as the basis for reporting within the LULUCF context.

In addition, land use and land-use changes have been completely recalculated for the period 1990 through 2000, since inconsistencies had previously occurred, as a result of use of different data sources, in designation of land-use / land-use-change areas in CRF sectors 5.B – 5.F.

At the same time, although the approach selected for the present submission is spatially and chronologically consistent, it is still only an interim solution. Germany plans to convert its LULUC reporting system in the next two years, with a view to:

- Standardisation,
- Avoidance of the artifacts that can result from mixing of different approaches,
- Obtaining a maximally precise, standardised description of the entire report period, especially for the years 1990 – 2000,
- Establishment of complete consistency between KP reporting and UNFCCC reporting, and
- Simplification.

The following figures provide an overview, designed to facilitate orientation, of the complex interrelationships applying within the German LULUCF reporting system. Figure 46 summarises the relevant data sources, activity data, emission factors and allocation of land-use categories and subcategories to the IPCC categories, while Figure 47 shows possible land-use changes, along with algorithms for calculating the relevant emissions or storage of CO₂. Chapters 7.2 – 7.7 and 19.5 describe the reporting system's data sources and methods in detail.

	Area data	Biomass data	Soil data
Forest	Old Länder : BWI 1 + 2 New Länder: remote sensing + BWI 2	Old Länder: BWI 1 + 2 + inventory study 2008 New Länder: Datenspeicher data + BWI 2 + IS08	BZE 1 + 2 + Biosoil Org. soils: IPCC standard
Cropland Annual crops Horticulture Special crops	ATKIS since 2000 1990 – 2000 backward extrapolation in LULUC	Harvest data from agricultural statistics	Mineral soils: soil type from BÜK 1000; soil-type-specific C stocks; overlaying with ATKIS for each sub-class Organic soils: national emission factors
		IPCC standard	
Grassland Meadows and pastures Heath Woods		Mean harvest (constant)	
		IPCC standard	
Wetlands Bogs Marshes and reed beds Peat extraction Open water areas		Expert assessment	Zero
		Zero	
Settlements 11 sub-classes		Zero; mixtures of forest and grassland	
Other (unused)		Zero	Like croplands, grasslands wetlands

Remark: The horizontal lines in the data categories delimit the categories and subcategories to which the relevant methods refer (for example: biomass data for cropland: data for annual crops and horticulture from agricultural statistics; data for special crops from IPCC standard).

Figure 46: Overview of land-use categories and subcategories, and of data sources, activity data and emission factors in the German LULUCF reporting system

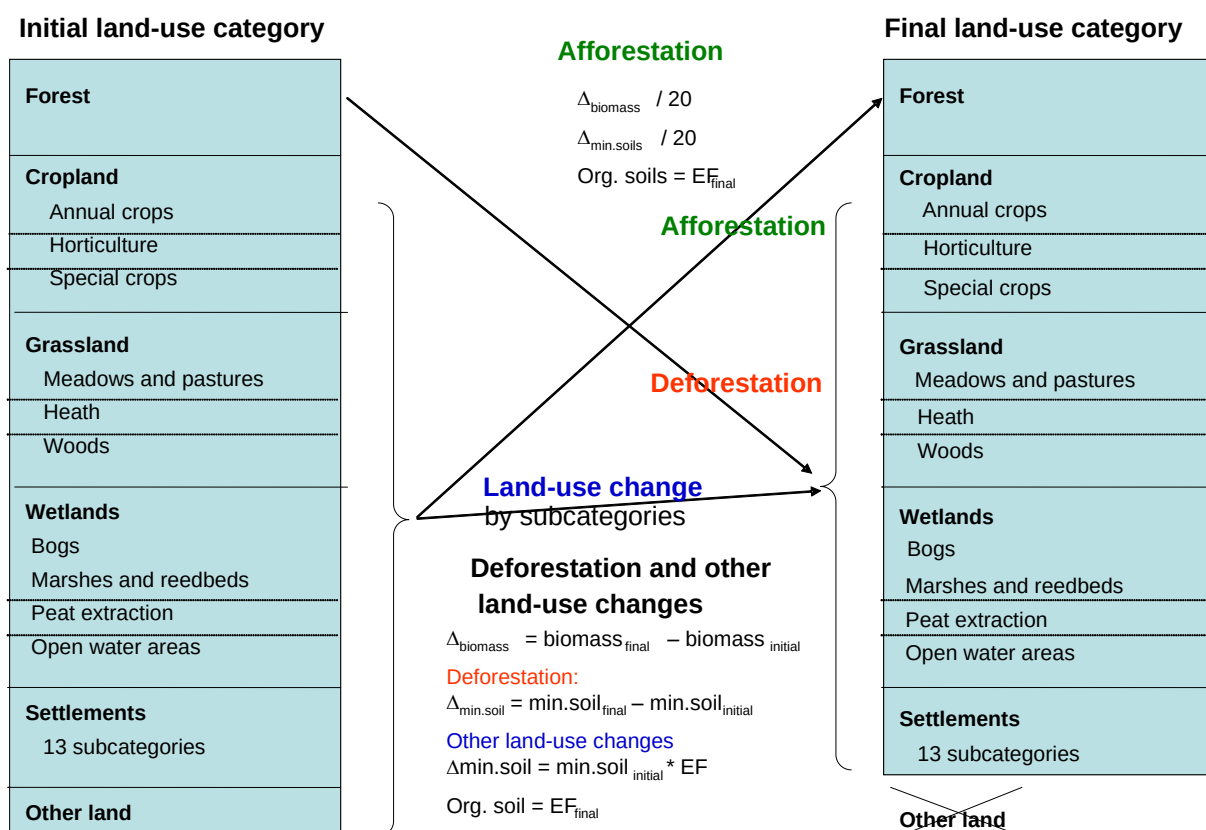


Figure 47: Overview of possible land-use changes, as well as of algorithms for estimating the relevant emissions and binding of CO₂.

Figure 48 shows the development of emissions in the LULUCF sector. The change seen, from a sink to a source, is due primarily to a marked reduction in forests' sink function. The slight increase seen in the LULUC sector is the result of a considerable increase in emissions from grassland. Details on these developments are provided in the relevant chapters.

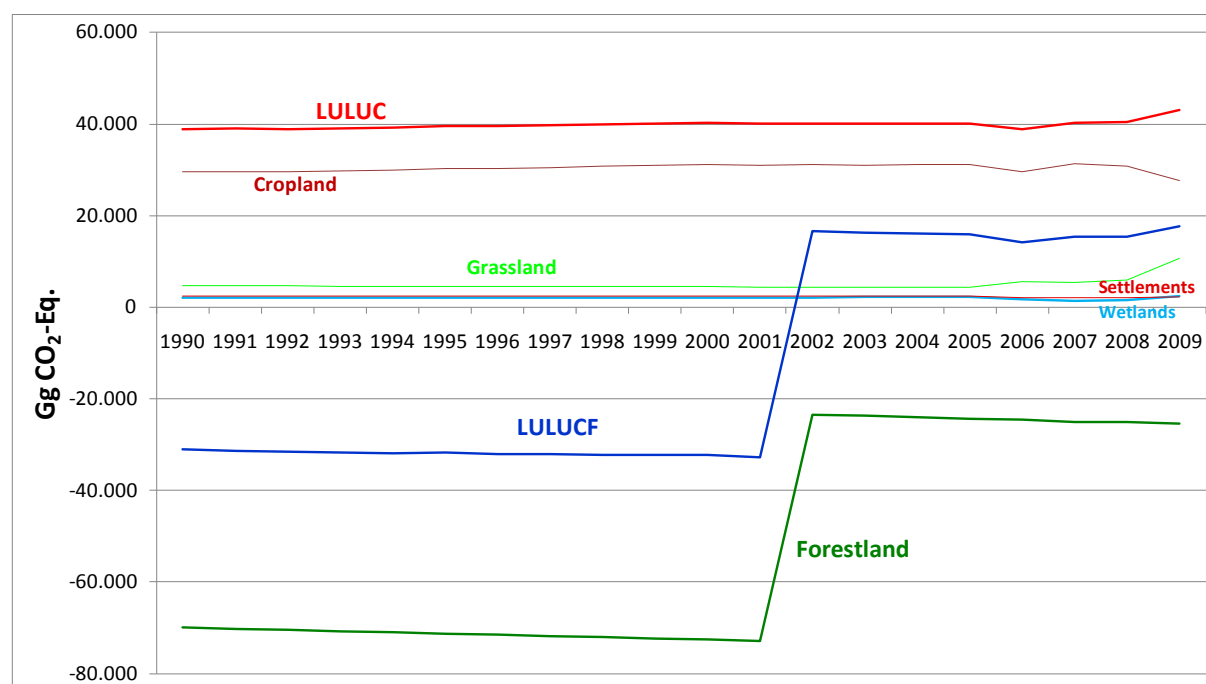


Figure 48: Emissions development in the LULUCF sector since 1990

7.2 Forest land (5.A)

7.2.1 Source category description (5.A)

CRF 5.A					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (HQG)	1990 - Contribution to total emissions	2009 - Contribution to total emissions	Trend
Forest Land	l / t / T2	CO ₂	5.74 %	2.72 %	-52.7 %

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS	D				D				
EF uncertainties in %		50				50				
Distribution of uncertainties		N				N				
EF-determination method	CS/T2 ⁶⁰	T1				T1/T2				

The source categories *Forest Land Remaining Forest Land* (5.A.1) und *Land Converted to Forest Land* (5.A.2) are key sources for CO₂ emissions pursuant to GPG-LULUCF (IPCC, 2003).

In the Good Practice Guidance for Land use, Land-use Change and Forestry (GPG-LULUCF, IPCC, 2003), and in the official reporting tables, in the "Common Reporting Format" (CRF), for the greenhouse-gas inventories sent to the Climate Secretariat, the category "forest" is divided into "Forest Land Remaining Forest land" (forest that remains forest during the period covered by the report) and "Land Converted to Forest Land" (new forest created, via afforestation or natural succession, on areas previously used for other purposes).

7.2.1.1 Forest land remaining forest land (5.A.1)

"Forest land remaining forest land" refers to the forest area that remains forest in the report year. It differs from the total forest area in that it does not include new forest land, which is considered in a separate category (see Chapter 7.2.1.2).

7.2.1.2 Land converted to forest land (5.A.2)

Forest is created through succession, afforestation and reforestation; new forest areas begin storing C equivalents as soon as they are converted. Pursuant to IPCC GPG-LULUCF (2003), new forest remains for at least 20 years within this category, after which it is transferred to the "forest land remaining forest land" category.

It must be remembered that the C stocks of the biomass from previous land uses are deducted. The relevant figures were calculated by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTi-AK). Relevant information is provided in chapters 7.3 through 7.7.

7.2.2 Information about the approaches used to determine forest area and about the land-use databases used (5.A)

The following data sources were used for determination of forest areas; for determination of land-use changes that have occurred; for estimation of the relevant emission factors for soil, biomass, ground cover and dead wood; and for calculation of carbon stocks and stock changes at various times and over various periods:

⁶⁰ The entry "CS/T2" refers to determination of changes in carbon stocks in biomass, dead wood and forest ground cover. Under Tier 1, changes in dead wood, forest ground cover and soil were estimated to be 0.

- National Forest Inventory 1 (Bundeswaldinventur; BWI 1)
- National Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventurstudie 2008 (IS08; Inventory Study)
- Datenspeicher Waldfonds (DSW)
- Bodenzustandserhebung im Wald I (BZE I; survey of soil condition in forests)
- Bodenzustandserhebung im Wald II (BZE II; survey of soil condition in forests)
- Soil-inventory data from the project BioSoil (BioSoil)
- GSE Forest Monitoring⁶¹ : Inputs for national greenhouse-gas reporting (GSE FM-INT)
- Amtliches Topographisch-Kartographisches Informationssystem (ATKIS®; Official topographic-cartographic information system)
- Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000 (BÜK 1000; overview soil map for the Federal Republic of Germany)
- Forest-fire statistics of the Federal Republic of Germany
- Fertiliser statistics of the Federal Statistical Office

7.2.2.1 National Forest Inventory, Inventurstudie 2008 and Datenspeicher Waldfonds

The National Forest Inventory surveys conditions of forests, and of forest production potential, on a large scale throughout Germany, using a standardised sampling procedure. The National Forest Inventory is a terrestrial sampling inventory that uses permanently marked sampling points in a 4 km x 4 km basic grid whose resolution, at the request of the Länder, can be increased on a regional basis⁶². The first National Forest Inventory (BWI 1) covered only the territory of the Federal Republic of Germany, in its pre-1990 borders, and West Berlin. It was carried out in the period 1986 to 1989 (sample year 1987). The second National Forest Inventory (BWI 2) was carried out in the period 2001 to 2003 (sample year 2002), as a repeat inventory in the old German Länder and as a first inventory in the new German Länder (BMVEL, 2001; BMELV, 2005).

In 2008, in order to obtain current forest-condition data as of the beginning of the commitment period under the Kyoto Protocol, the Inventurstudie 2008 (IS08), an interim inventory based on the National Forest Inventory, was carried out over an 8 km x 8 km sampling grid (SCHWITZGEBEL et al. 2009, BMELV 2010).

The Datenspeicher Waldfonds (DSW) contains complete-coverage forestry data for the territory of the former GDR until 1993. Its data were collected periodically and updated annually, on the basis of growth models and of implementation and change reports of the country's forestry operations (BMELF, 1994).

7.2.2.2 Survey of forest soils (BZE and BioSoil)

Carbon emissions from forest soils have been determined via the stock-changes method (IPCC 2003). In addition, data from three soil surveys, BZE I, BioSoil and BZE II, have been used. The BZE I soil survey was carried out from 1987 to 1992, BioSoil was carried out from 2006 to 2007 and BZE II was carried out from 2006 to 2008. In all three inventories, samples were taken of both total organic cover, referred to in the following as "ground cover",

⁶¹ GSE =GMES Services Elements

GMES = Global Monitoring for Environment and Security

⁶² Further information: <http://www.bundeswaldinventur.de>

pursuant to IPCC (2003), and of mineral soils. The data for the three inventories were collected by the Länder.

In the BZE I (WOLFF & RIEK 1996) and BZE II (WELLBROCK et al. 2006), forest soils throughout Germany were sampled within an 8 km x 8 km grid. In the sampling procedure, at each grid point, eight satellite samples were taken, within a 10 m radius around a central excavation with an exposed soil profile. In the BZE I, the total number of grid points was 1800, while in the BZE II it was 2000. The main reason for the difference, between the two inventories, in the number of samples is that in the second of the two surveys access was gained to areas that had previously been off-limits (for example, old military training areas have been opened for access).

In the period during which the BZE II was carried out, the BioSoil survey (UN-ECE 2006), covering 425 points in a 16 km x 16 km grid, was also carried out. The sampling and analysis methods for that survey were similar to those used in the BZE II. For the most part, corresponding grid points for the three inventories all lay, in each case, within a 30 m radius. For some 400 points, a systematic grid shift with respect to the BZE I occurred.

While for the BZE I a database is now available with some 1800 points for which carbon stocks for ground cover and mineral soil (0 – 30 cm) have been calculated (WOLFF & RIEK 1996), the Länder have not yet completed transmitting BZE II survey data to a joint national database. For the BZE II, data from some 950 grid points are available for calculation of carbon stocks. Those data, in combination with the BioSoil data, provide a body of some 1100 grid points at which it was possible to calculate carbon stocks for the years 2006 and 2007. Relevant analyses, and assessment in co-operation with Länder experts, have not yet been completed.

7.2.2.3 GSE Forest Monitoring: Inputs for national greenhouse-gas reporting

The GSE Forest Monitoring project is part of the Global Monitoring for Environment and Security (GMES) programme, which was established in 1998 by the European Commission and the European Space Agency (ESA). An effort being carried out under the direction and control of the European Union, and in partnership with the Member States and ESA, GMES is aimed primarily at creating services that provide access to precise environmental / security-relevant data and information and are tailored to users' requirements. In the framework of the GSE Forest Monitoring project, the service "Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT; "Wald Monitoring: Inputs für die Nationale Treibhausgasberichterstattung") has been introduced for the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). The products of that service have included maps of forest cover, land use and land-use changes, for 1990 and for pertinent changes through 2002 and 2005/06; area statistics; and error analyses for the new Länder (GSE 2003, GSE 2006, GSE 2007, GSE 2009). Further information about the GSE FM-INT project is provided in Chapter 19.5.1.1.

7.2.2.4 Amtliches Topographisch-Kartographisches Informationssystem (ATKIS®; Official topographic-cartographic information system)

The Official Topographic-Cartographic Information System (Amtliches Topographisch-Kartographisches Informationssystem), a system for digital management of results of topographic land surveys and of official topographic maps, has been developed by the surveying authorities of the Länder and by the Federal Agency for Cartography and Geodesy

(BKG). On an ongoing basis, it is enhanced and updated. Surveying authorities of the Länder continually add new land-use-change data to it. A more detailed description is provided in Chapter 19.5.2.1.1.3.

7.2.3 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.A)

The basis for reporting consists of the definition of "forest" used by the National Forest Inventory (Bundeswaldinventur (BWI); BMVEL, 2001):

"Forest" within the meaning of the BWI is any area of ground covered by forest vegetation, irrespective of the information in the relevant cadastral survey or similar records. The term "forest" also refers to cutover or thinned areas, forest tracks, firebreaks, openings and clearings, forest glades, feeding grounds for game, landings, rides located in the forest, further areas linked to and serving the forest including areas with recreation facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures and rough pastures, as well as areas of dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50% of the area is covered by forest. Forested areas of less than 1,000 m² located in farmland or in developed regions, narrow thickets less than 10 m wide, Christmas tree and decorative brushwood cultivations and parkland belonging to residential areas shall not constitute forest within the meaning of the BWI. Watercourses up to 5 m wide do not break the continuity of a forest area.

At the same time, in a departure from the BWI definition of "forest", areas that the BWI counts as forest, but places in the forest category "non-forest ground", i.e. because they are not wooded, were not taken into account in calculation of carbon stocks and carbon-stock changes.

It must be noted that, pursuant to IPCC GPG-LULUCF (2003), new forest remains for at least 20 years in the "new forest" category before it is transferred to the "forest land remaining as forest land" category. Since no afforestation-area data for all of Germany (i.e. both the old German Länder and the new German Länder) are available for the period prior to 1990, new forest land can be taken into account only as of 1990. For this reason, the areas that are converted to forest (= new forest), within the various land-use categories, have been growing continually.

7.2.3.1 Determination of forest area, and changes in that area, for the old German Länder

The BWI 1 data were collected on the territory of the old German Länder with reference to 1987. In the BWI 2, which was oriented to 2002, the sampling points included in the first BWI were re-sampled, and the forest areas of the new German Länder were surveyed for the first time. As a result, the BWI provides a basis for quantifying changes in forest land, including changes to and from other land-use categories, for the old German Länder. Such quantification is achieved by identifying the applicable land-use categories, as of the sampling times for both the BWI 1 and BWI 2, and determining the resulting land-use changes or lack thereof. Each sampling point represents an area for which the forest cover and area changes can be determined. For the new German Länder, the relevant data begin with forests' status as of 2002. As a result, this method cannot be used to determine changes in forest land in those areas (cf. Chapter 7.2.3.1).

The development of the total forest area, and of the various individual change categories, was derived via interpolation for the period 1987 to 2002, on the basis of the data from BWI 1 and BWI 2. Throughout that period, the same rate of change was assumed for each year in question. In addition, trends that offset each other are not taken into account. The resulting changes are extrapolated until 2009. Table 188 shows the area matrix for forest land remaining forest land, and for land converted to forest land, obtained with annual data for the years from 1990 through 2009, for the old German Länder. It is important to note that the areas in the change categories are accumulated, since such areas remain 20 years in their respective categories. Conversions of forest to other land-use categories are shown in Table 189. Since those areas are not accumulated, annual change areas can be given for the years 1990 through 2009.

Table 188: Forest area, forest land remaining forest land and conversions from other land-use categories to new forest land, in the old German Länder, from 1990 through 2009

Year	Forest Area [ha]	Forest Land remaining Forest Land [ha]	Cropland converted to Forest Land [ha]	Grassland converted to Forest Land [ha]	Wetlands converted to Forest Land [ha]	Settlements converted to Forest Land [ha]	Other Land converted to Forest Land [ha]
1990	7,881,966	7,872,944	1,977	3,669	1,166	2,209	0
1991	7,885,538	7,867,494	3,955	7,338	2,333	4,418	0
1992	7,889,110	7,862,043	5,932	11,007	3,499	6,627	0
1993	7,892,681	7,856,592	7,910	14,675	4,666	8,836	0
1994	7,896,253	7,851,142	9,887	18,344	5,832	11,045	0
1995	7,899,824	7,845,691	11,865	22,013	6,999	13,254	0
1996	7,903,396	7,840,241	13,842	25,682	8,165	15,463	0
1997	7,906,968	7,834,790	15,820	29,351	9,332	17,672	0
1998	7,910,539	7,829,339	17,797	33,020	10,498	19,881	0
1999	7,914,111	7,823,889	19,775	36,689	11,665	22,090	0
2000	7,917,682	7,818,438	21,752	40,357	12,831	24,299	0
2001	7,921,254	7,812,988	23,730	44,026	13,998	26,508	0
2002	7,924,825	7,807,537	25,707	47,695	15,164	28,717	0
2003	7,928,397	7,802,086	27,685	51,364	16,331	30,926	0
2004	7,931,969	7,796,636	29,662	55,033	17,497	33,135	0
2005	7,935,540	7,791,185	31,640	58,702	18,664	35,344	0
2006	7,939,112	7,785,735	33,617	62,370	19,830	37,553	0
2007	7,942,683	7,780,284	35,595	66,039	20,997	39,762	0
2008	7,946,255	7,774,833	37,572	69,708	22,163	41,971	0
2009	7,949,827	7,769,383	39,550	73,377	23,330	44,180	0

Table 189: Annual rates of conversion from forest land to other land-use categories, in the old German Länder

Period	Forest Land converted to Cropland [ha a ⁻¹]	Forest Land converted to Grassland [ha a ⁻¹]	Forest Land converted to Wetlands [ha a ⁻¹]	Forest Land converted to Settlements [ha a ⁻¹]	Forest Land converted to Other Land [ha a ⁻¹]
1990-2009	369	1,705	631	2,746	0

7.2.3.2 Determination of forest area, and changes in forest area, in the new German Länder

The GSE maps (cf. Chapter 7.2.2.3) show the land-use changes in the new German Länder in the period 1990 to 2005/06. A single exception applies with regard to land-use changes in the eastern part of the State of Saxony – they were determined only for the period 1990 through 2002. In a procedure similar to that used for the old German Länder, a constant annual rate of change was assumed for the individual years in question, and it was calculated via interpolation for the period between 1990 and 2005 and via extrapolation for the period between 2005 and 2009. Table 194 shows the "forest land remaining forest land" and new-forest areas in the new German Länder, for each year from 1990 to 2009. Since newly afforested areas remain 20 years in their relevant change categories, the areas are accumulated. Conversions of forest to other land-use categories are shown in Table 191.

Since those areas are not accumulated, annual change areas can be given for the years 1990 through 2009.

Table 190: Forest area, forest land remaining forest land and conversions from other land-use categories to new forest land, in the old German Länder, from 1990 through 2009

Year	Forest Area [ha]	Forest Land remaining Forest Land [ha]	Cropland converted to Forest Land [ha]	Grassland converted to Forest Land [ha]	Wetlands converted to Forest Land [ha]	Settlements converted to Forest Land [ha]	Other Land converted to Forest Land [ha]
1990	3,134,785	3,125,956	224	8,434	41	129	0
1991	3,142,087	3,124,429	449	16,869	82	258	0
1992	3,149,389	3,122,903	673	25,303	123	387	0
1993	3,156,691	3,121,376	897	33,738	164	517	0
1994	3,163,994	3,119,850	1,122	42,172	204	646	0
1995	3,171,296	3,118,323	1,346	50,606	245	775	0
1996	3,178,598	3,116,797	1,570	59,041	286	904	0
1997	3,185,900	3,115,270	1,795	67,475	327	1,033	0
1998	3,193,202	3,113,744	2,019	75,910	368	1,162	0
1999	3,200,505	3,112,217	2,243	84,344	409	1,291	0
2000	3,207,807	3,110,691	2,468	92,778	450	1,421	0
2001	3,215,109	3,109,164	2,692	101,213	491	1,550	0
2002	3,222,411	3,107,637	2,916	109,647	532	1,679	0
2003	3,229,714	3,106,111	3,141	118,082	573	1,808	0
2004	3,237,016	3,104,584	3,365	126,516	613	1,937	0
2005	3,244,318	3,103,058	3,589	134,950	654	2,066	0
2006	3,251,620	3,101,531	3,814	143,385	695	2,195	0
2007	3,258,922	3,100,005	4,038	151,819	736	2,325	0
2008	3,266,225	3,098,478	4,262	160,254	777	2,454	0
2009	3,273,527	3,096,952	4,487	168,688	818	2,583	0

Table 191: Annual rates of conversion from forest land to other land-use categories, in the new German Länder

Period	Forest Land converted to Cropland [ha a ⁻¹]	Forest Land converted to Grassland [ha a ⁻¹]	Forest Land converted to Wetlands [ha a ⁻¹]	Forest Land converted to Settlements [ha a ⁻¹]	Forest Land converted to Other Land [ha a ⁻¹]
1990-2009	23	85	105	1,314	0

7.2.4 Methodological issues (5.A)

7.2.4.1 Biomass

7.2.4.1.1 Forest land remaining forest land

For the old German Länder, and for the period until 2002, relevant data are available from two national forest inventories (key dates: 1 October 1987 and 1 October 2002). Between BWI 1 and 2, C stocks increased by 1.35 MgC ha⁻¹ a⁻¹ in the forests of the old German Länder. The increase in stocks is a result of low use, in comparison to growth. For the new German Länder, data from the National Forest Inventory 2 (BWI 2) were compared with data from the Datenspeicher Waldfonds (DSWF) database, given the lack of an initial inventory

comparable to BWI 1. The comparison showed a marked net increase in carbon stocks, amounting to $2.52 \text{ MgC ha}^{-1} \text{ a}^{-1}$. As of 2002, data from the BWI 2 inventory and the Inventurstudie 2008 (IS08) study are available for calculation of changes in stocks for Germany as a whole. On the basis of this information, a C-stock increase of $0.44 \text{ MgC ha}^{-1} \text{ a}^{-1}$ was calculated for the territory of Germany as a whole.

Nonetheless, the forests' function as a sink has decreased markedly as a result of forest management. The relevant effects include a near doubling of harvested quantities. In the first inventory period (1987 – 2002), for example, an average of about 47.9 million m^3 (cubic metres of standing timber) were harvested per year in the old German Länder, while some 89.0 million m^3 were harvested in the 2002 – 2008 inventory period.

Logging statistics for Germany as a whole – although their data are somewhat distorted (cf. Dieter 2005) – show a similar trend, with an average of 39 million m^3 (Efm = cubic metres of harvested timber, i.e. with bark and cutting losses deducted) in the period 1991 – 2001 and an average of 58 million m^3 (Efm) in the period 2002 – 2008 (cf. Table 190).

Table 192: Raw-wood production pursuant to logging statistics of the Federal Statistical Office (Destatis)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Raw-wood production (millions of m^3)	35.6	34.3	37.1	40.0	37.0	38.2	39.1	37.6	53.7	39.1
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Raw-wood production (millions of m^3)	42.4	51.2	54.5	56.9	62.3	76.7	55.4	48.1	39.5	

Figure 49 shows the carbon stocks for the three inventory times. The data for 1987 and 1993 come from the BWI 1 or the DSWF; data for 2002 come from the BWI 2; and data for 2008 come from the IS08. These figures, which take account of both forest land remaining forest land and new forest land, also highlight the increase in forest carbon stocks.

Overall, the forests of the Federal Republic of Germany are thus a net sink for carbon.

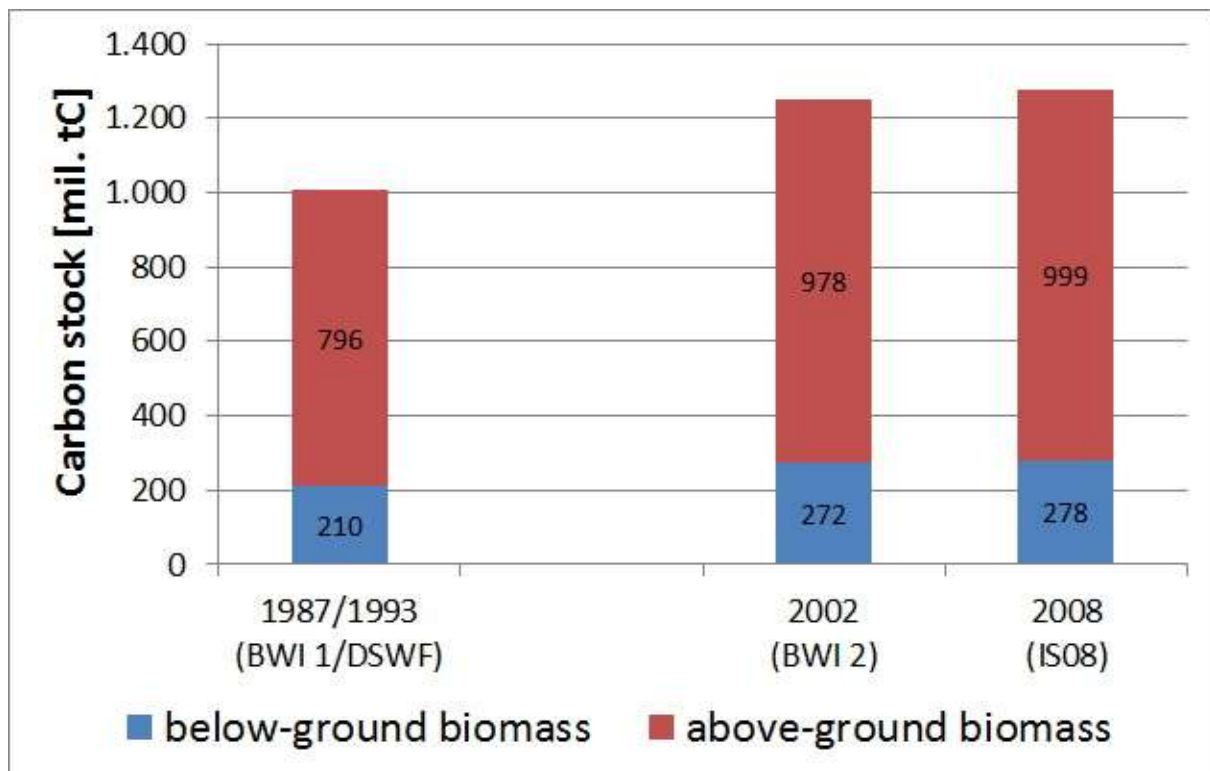


Figure 49: Carbon stocks in below-ground and above-ground biomass, in forest, in the years 1987/1993, 2002 and 2008

7.2.4.1.2 New forest land

With regard to new forest land, an individual-tree calculation was carried out on the basis of the BWI 1 and BWI 2 inventories. Only trees in the old German Länder were taken into account, since the BWI 1 inventory was carried out only there. The carbon stocks were calculated for each area on which conversion from a given land use to forest land took place, and then all the resulting stocks were combined within the "new forest land" category. The stocks of earlier-use categories were deducted – and thus taken into account.

Since it was not possible, for the new German Länder, to derive new-forest wood stocks directly from comparison of two inventories, the relevant values for the old German Länder were used.

The biomass stocks at the end of the 2002 vegetation period represent the increase in stocks in biomass throughout the entire period under consideration since 1987. That increase in stocks was linearly interpolated/extrapolated throughout the period 1990 to 2009. The C-stock increase, for the entire afforested area, is $4.15 \text{ MgC ha}^{-1} \text{ a}^{-1}$ per year. It must be remembered that afforested areas remain in this land-use category for 20 years; this is why the area increases each year. On the areas added each year, the C-stock losses from previous uses must be taken into account; those losses are immediately assessed as emissions. The C stocks from previous uses, as determined by the Institute of Agricultural Climate Research (vTI-AK), are summarized in Table 193 (cf. Chapter 7.3.4.3).

Table 193: Carbon stocks from previous uses

Time period [year]	C stocks [MgC ha ⁻¹ a ⁻¹]
1990-2005	18.94
2006	18.56
2007	16.65
2008	20.25
2009	20.29

In the 2008 inventory study (Inventurstudie), no cluster screening – which is normally aimed, for example, at identifying clusters on new forest land – was carried out. For this reason, no new-forest areas were identified. In addition, no samples with individual-tree data were available for the period from 2002 (BWI 2) through 2008 (IS08). Values for that period were calculated via extrapolation of data from the BWI 1 and BWI 2 surveys. It did prove possible to use IS08 data to deduce new-forest areas, and their status, prior to 2002. That, in turn, made it possible to determine net growth on those areas in the period from 2002 through 2008. It amounted to 4.95 MgC ha⁻¹ a⁻¹. As mentioned above, it was not possible to take new-forest areas as of 2002 into account, and thus this net-growth figure does not include those areas' growth. For this reason, this update value was not included in reporting.

7.2.4.1.3 Derivation of individual-tree biomass

For calculation of carbon stocks, data from BWI 1 (some 230,000 measured trees) were used for the old German Länder as of the 1987 sampling year. For the new German Länder, data on forest establishment through 1993 are available in aggregated form, in the Datenspeicher Waldfonds database, that can be used for calculations of C stocks. The BWI 2 survey, in which some 377,000 trees were measured, provides the database for the 2002 sampling year for Germany. Those data sources provide such a good basis for calculating estimated C-stock changes that it was preferable to use the stock-change method instead of the default method (IPCC, 2003: p. 3.24). The BWI data have been supplemented with repeat-survey data for some 83,000 trees, from the Inventurstudie 2008.

Forest surveys often collect volume data – and often collect such data with reference to useful dimensions. For purposes of greenhouse-gas reporting, data on carbon mass in trees is required, and such data cannot be obtained via direct measurement. Consequently, the biomass of a given tree is estimated via a step-by-step procedure – for example, via biomass functions that can be applied to measured inventory data. These functions directly yield tree dry masses, usually with the input quantities breast-height diameter (BHD) and height (H). In a second step, the so-determined biomass is multiplied by its carbon content, to obtain the entire C mass in the relevant individual tree. Unfortunately, findings from biomass studies carried out to date are based on small numbers of samples; or have been obtained from trees growing in other climate zones (Scandinavia, Siberia, North America); and/or represent only local growth and site circumstances and applicable management options. Use of such data would thus produce distorted biomass estimates. For this reason, a procedure was applied (PISTORIUS et. al., 2006) whereby the standing-timber volume, as determined in the inventory, is converted into the above-ground tree volume. The above-ground tree volume includes branches and, for evergreen trees, the leaf organs. To estimate tree wood volumes from standing timber volumes, regression equations are used that describe the relationship between the above-ground standing-timber volume and the above-ground tree wood volume. These volume-expansion functions were derived from the tables of GRUNDNER &

SCHWAPPACH (1952), which are based on an extensive database comprising 71,051 trees. In spite of its age, that database is still assumed to be the most suitable database for Germany at present.

In a next step, the above-ground biomass of individual trees was estimated by multiplying the standing-timber volume by the applicable volume density. Density data from KOLLMANN (1982), for specific tree-species groups, were used for that purpose. Since those data include spreads, they support error analysis via triangular distribution. With this method, the greater volume densities found in branches (HAKKILA, 1972) can be taken into account, since the difference between tree-wood volume and standing-timber volume correlates with branch mass. That separation was carried out for the densities pursuant to KOLLMANN (1982).

The underground living biomass was taken into account via stock-mass relationships. To this end, the above-ground biomass, broken down by tree species, was aggregated to hectare values for each random-sample point. The resulting values were multiplied with the IPCC standard values (IPCC, 2003, Table 3A.1.8), for derivation of root biomass.

For use of the stock-change method, the relevant living biomass was divided into the categories of standing-timber volume, branch-wood volume and root mass. Above-ground volumes were converted into masses using specific volume densities for the various tree species in question. Equation 9 and Equation 10 for C-stock determination via the stock-change method were thus converted, pursuant to PISTORIUS et al. (2006), into the form exhibited by Equation 11. The first term of that equation (standing timber, branch wood) was applied to each tree, and the results were aggregated to obtain values for entire plantations. The plantation values, broken down by tree-species groups, were used to derive the below-ground biomass for the second term of Equation 16.

Equation 9

$$\Delta C = (C_{t_2} - C_{t_1}) / (t_2 - t_1)$$

Equation 10

$$C = (D * rd * BEF) * (1 + R) * CF$$

Equation 11

$$C = (D * rd_{stem} + D * rd_{branch} * (VEF - 1)) * (1 + R) * CF$$

where:

C	= Carbon stock
t	= Time at which an inventory is taken
D	= Standing-timber volume
rd_{stem}	= Stem wood density
rd_{branch}	= Branch wood density
BEF	= Biomass-expansion factor
VEF	= Volume-expansion factor ⁶³
R	= Root / sprout relationship
CF	= carbon content

⁶³ The biomass-expansion factor (BEF) is used here in keeping with IPCC. In the literature, the term "BEF" is used in a variety of very different ways. For this reason, in the following, the term "volume-expansion factor" (VEF) is used, which describes the relationship "above-ground volume / standing-timber volume".

7.2.4.1.4 Conversion into above-ground individual-tree biomass

The standing-timber volume D of each individual tree is derived, with the help of the BWI-volume function, via the parameters breast-height diameter (BHD), tree height (H) and diameter at a height of 7 m (D_7). The standing-timber volume D is converted to biomass (in tonnes) via bulk-density values rd_{stem} for each relevant tree-species group. The bulk-density values are derived, via the formula

Equation 12

$$r = r_0(1 - \beta_v / 100)$$

where:

r	= Bulk density
r_0	= Raw density
β_v	= Volume-loss measure,

as a function of the volume-loss measure, and from the raw densities given in KOLLMANN (1982). The raw densities pursuant to KOLLMANN (cf. Table 194) give the raw-density ranges and their average values for the most important tree species. The aforementioned ranges provide the basis for deriving the error framework that results via conversion of standing-timber volume into biomass. Table 194 lists bulk densities pursuant to IPCC and KNIGGE & SCHULZE (1966) by way of comparison. While those figures are comparable to those given by KOLLMANN (1982), they do not yield error data.

Table 194: Bulk densities ρ_d in [g/cm³], as given by IPCC (2003), KOLLMANN (1982) and KNIGGE & SCHULZ (1966)

Genus	Species	Stem (IPCC)	Branch (IPCC)	Stem (Kollmann)	Branch (Kollmann)	Knigge & Schulz (branch and stem)	β_V [%] (Kollmann)
Picea	abies	0.40	0.54	0.38	0.51	0.38	11.9
Picea	(other)	0.40	0.54	0.38	0.51	0.38	11.9
Pinus	sylvestris	0.42	0.56	0.43	0.58	0.43	12.1
Pinus	strobus	0.32	0.43	0.43	0.58	0.43	12.1
Pinus	(other)	0.42	0.56	0.43	0.58	0.43	12.1
Abies	alba	0.40	0.54	0.36	0.49	0.37	11.5
Abies	(other)	0.40	0.54	0.36	0.49	0.37	11.5
Pseudotsuga	menziesii	0.45	0.60	0.41	0.56	0.41	11.9
Larix	decidua	0.46	0.62	0.49	0.66	0.49	11.4
Larix	kaempferi	0.49	0.66	0.49	0.66	0.49	11.4
Thuja	spec.	0.31	0.42	0.38	0.51	0.38	11.9
Tsuga	spec.	0.42	0.56	0.38	0.51	0.38	11.9
Coniferous trees	(other)	0.40	0.54	0.38	0.51	0.38	11.9
Fagus	sylvatica	0.58	0.64	0.56	0.61	0.55	17.9
Quercus	robur	0.58	0.62	0.57	0.61	0.56	12.2
Quercus	petraea	0.58	0.62	0.57	0.61	0.56	12.2
Fraxinus	exelsior	0.57	0.60	0.56	0.60	0.56	13.2
Carpinus	betulus	0.63	0.69	0.64	0.70	0.56	18.8
Acer	spec.	0.52	0.57	0.52	0.57	0.56	11.5
Tilia	spec.	0.43	0.47	0.42	0.46	0.56	12.1
Robinia	pseudoacacia	0.58	0.64	0.65	0.71	0.56	11.5
Ulmus	spec.	0.51	0.54	0.56	0.59	0.56	14.9
Castanea	sativa	0.48	0.51	0.56	0.59	0.56	11.4
Betula	spec.	0.51	0.56	0.53	0.58	0.38	13.2
Alnus	spec.	0.45	0.49	0.43	0.47	0.38	17.9
Populus	spec.	0.35	0.38	0.35	0.39	0.38	13.7
Salix	spec.	0.45	0.49	0.46	0.51	0.38	13.7
Prunus	spec.	0.49	0.54	0.56	0.61	0.38	12.6
Deciduous trees	(other)	0.58	0.64	0.56	0.61	0.38	13.7

The standing-timber volume D was expanded into the above-ground tree wood volume B via the functions published in PISTORIUS et al. (2006) for derivation of volume-expansion factors (VEF). As used, the functions have the form

Equation 13

$$VEF = B / D = (a + bD) / D$$

The parameters a and b for calculation of VEF are listed in Table 195.

Table 195: Models for deriving volume-expansion factors

Model	a	b
Birch	0.017493	1.121933
Beech, age to 60	0.011942	1.207371
Beech, age 61 to 100	0.008184	1.196184
Beech, age at least 101	0.030255	1.128104
Oak	0.101879	1.051529
Alder	0.004825	1.068903
Spruce, age to 60	0.036697	1.148143
Spruce, age at least 61	0	1.177947
Pine, age to 80	0.009946	1.156659
Pine, age at least 81	0.036883	1.076103
Fir, age to 80	0.019457	1.168262
Fir, age 81 to 120	0	1.228069
Fir, age at least 121	0	1.219492
Larch	0.063265	1.057712

The difference between tree wood volume and standing-timber volume is defined as branch wood. Due to the stresses it is subject to, branch wood is denser than trunk wood. Differentiation of categories makes it possible to use branch-wood densities that differ from standing-timber densities. The necessary data were derived by analogy to HAKKILA (1972), who divides trees by physiological groups – into conifers, ring-porous deciduous trees and diffuse-porous deciduous trees. Table 196 shows average values for 8 conifers, 8 ring-porous deciduous trees and 4 diffuse-porous deciduous trees. A relationship for these physiological tree-species groups was derived, and the basic densities pursuant to KOLLMANN (1982) were correspondingly increased.

Table 196: Wood densities for branch wood

	Stem wood [g/cm ³]	Branch wood [g/cm ³]	Ratio, Branch density / stem density
Conifers	0.36	0.49	1.34
Diffuse-porous deciduous trees	0.49	0.54	1.1
Ring-porous deciduous trees	0.54	0.57	1.06

The above-ground biomass B_o for a given individual tree, therefore, is obtained as the sum of the standing-timber biomass and the branch-wood biomass, via the following equation:

Equation 14

$$B_o = D * rd_{stem} + D * \left(\frac{a + bD}{D} - 1 \right) * rd_{branch}$$

7.2.4.1.5 Conversion into below-ground biomass

In contrast to derivation of above-ground biomass, the root dry substance was not calculated via a volume and the basic density; instead, it was established directly from the above-ground mass. Dry-root substance was estimated using the root/shoot ratio, at the plantation level, with values from Table 3A.1.8 IPCC (2003) (cf Table 197). To obtain plantation values, the above-ground biomass, differentiated by tree-species groups, was extrapolated to the

hectare level for each sampling point, and then the below-ground biomass was derived. An advantage of the IPCC table is that it gives the standard error for estimates.

Root-biomass functions are another means of calculating below-ground biomass. Because root studies are so difficult to carry out, few relevant functions are available. For example, DIETER & ELSASSER 2002 published a function for estimating root biomass. In the main, this function is based on data, for temperate forests, of CAIRNS et al. (1997), KURZ et al. (1996) and VOGT et al. (1996). They achieved a random-sampling set of 272 root studies. The function of DIETER & ELSASSER (2002) was not used, however, because no error information for that function was given. A calculation comparing the function of DIETER & ELSASSER (2002) and the IPCC values is presented by DUNGER et al. (2010c).

Table 197: Root/shoot-ratio at the plantation level, pursuant to IPCC (2003)

Vegetation type	Above-ground biomass [t ha ⁻¹]	Mean	Standard error	Lower range	Upper range
Coniferous trees, plantations	<50	0.46	0.21	0.21	1.06
	50-150	0.32	0.08	0.24	0.50
	>150	0.23	0.09	0.12	0.49
Oak forest	>70	0.35	0.25	0.20	1.16
Other deciduous tree species	<75	0.43	0.24	0.12	0.93
	75-150	0.26	0.10	0.13	0.52
	>150	0.24	0.05	0.17	0.30

7.2.4.1.6 Conversion of individual-tree biomass into carbon

For conversion of biomass to C stocks, the IPCC default value, 0.5 (IPCC, 2003, Equation 3.2.3), was used. WIRTH et al. (2004) report that the differences between compartments, within one and the same tree species, are larger than the differences between tree species. They obtain a range of 0.50 to 0.56 gC g⁻¹ in conifers. The relative standard error for carbon content in wood is given by BURSCHEL et al. (1993) as 1 to 2 %; WEISS et al. (2000) use 2 %. Overall, therefore, 0.5 gC g⁻¹, with a relative standard error of ±2 %, seems appropriate as a good assumption for mean C content.

7.2.4.1.7 Algorithms for extrapolating to relevant states in 1987, 2002, 2008

At this juncture, we present the extrapolation procedures to be used in connection with a stratified sampling plan oriented to the values "standing-timber stocks", "biomass" and "carbon" at a given time. Stratification is required, since some Länder have increased the density of their sampling networks. The relevant approach uses "sampling strata". The relevant statuses are calculated for 1987, 2002 and 2008. The extrapolation algorithms used for different study units (entire territory of Germany, different regions (old/new German Länder) and different LULUCF and ARD classes) are identical.

The National Forest Inventory uses cluster sampling. The smallest sampling unit is the cluster, with four cluster corners (sampling points). Along the boundaries of an inventory area, or of strata, incomplete clusters, of varying sizes, will be found, i.e. the number of sampling points (cluster corners in forest and non-forest) within such clusters can vary between 1 and 4. For each cluster *c* located within a stratum *l*, the local density (*Y*) must be calculated first:

Equation 15

$$Y_{lc} = \frac{\sum_{m=1}^M I_{l,c,m} Y_{l,c,m}}{M_{l,c}}$$

where $M_{l,c}$ = number of sampling points in cluster c in stratum l . The mean estimator, with respect to forest and non-forest, for stratum l is then obtained as follows:

Equation 16

$$\hat{Y}_l = \frac{\sum_{c_l=1}^{C_l} M_{l,c} Y_{lc}}{\sum_{c_l=1}^{C_l} M_l}$$

The global estimator for a given value, throughout all strata ($\hat{Y}_{st}$) is the average of the individual stratum estimators, weighted with the area shares for the strata:

Equation 17

$$\hat{Y}_{st} = \sum_{l=1}^L \hat{Y}_l \frac{\lambda(U_l)}{\lambda(U)}$$

The total status estimate is obtained by multiplying the global estimator by the total area $\lambda(U)$.

Equation 18

$$\hat{Y}_{st} = \hat{Y}_{st} \lambda(U)$$

The (forest-) area-oriented mean is defined as the quotient or ratio estimator ($\hat{R}_{st}$); it is obtained as follows:

Equation 19

$$\hat{R}_{st} = \frac{\hat{Y}_{st}}{\lambda(U_{forest})}$$

7.2.4.1.8 Algorithms for extrapolating changes between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes via the "stock-change method")

For calculation of the changes between two time points, the "continuous forest inventory" (CFI) method was used, i.e. for extrapolation only those cluster sampling points were used that were included at both times. The change estimate is thus based on the difference between the two status estimates. At the stratum level, the total change is estimated as follows:

Equation 20

$$\hat{G}_l = \hat{Y}_l^{(t_2)} - \hat{Y}_l^{(t_1)}$$

The total change throughout all strata for a given study unit is estimated in the manner used in Equation 17. The estimated total change is calculated via Equation 18. The change in the area-oriented average is determined via:

Equation 21

$$\hat{G}_{Rst} = \hat{R}_{st}^{(t_2)} - \hat{R}_{st}^{(t_1)}$$

7.2.4.1.9 Interpolation of time periods, to obtain annual-change estimates

The National Forest Inventory (BWI; Bundeswaldinventur) is carried out periodically. Consequently, annual rates of change – "emission factors" – have to be obtained via interpolation between two time periods. For the time periods between BWI 1 (sample year 1987) and BWI 2 (sample year 2002) and the Inventurstudie 2008 study, linear interpolation was carried out at the level of the LULUCF and ARD classes. The emission factor *EF* for a LULUCF class is thus defined as the quotient of the area-oriented average and the number of years *a* within the relevant inventory interval:

Equation 22

$$EF = \hat{R}_{st}^{(t_1, t_2)} / a$$

A linear trend was also chosen in cases in which change estimates had to be extrapolated beyond an inventory period.

7.2.4.2 Dead wood

7.2.4.2.1 Forest land remaining forest land

The C stocks in dead wood were calculated with data of the BWI 2 (BMELV 2005) survey and the Inventurstudie 2008. The terrestrial survey used for BWI 2 included only: fallen dead wood with a thicker-end diameter of at least 20 cm; standing dead wood with a diameter of at least 20 cm at breast height (BHD); and trunks with either a height of at least 50 cm or a cut-surface diameter of at least 60 cm (BMVEL 2001). In keeping with requirements for climate reporting, in the Inventurstudie 2008 survey the survey threshold for dead-wood objects was reduced to a diameter of at least 10 cm at the thicker end (BMELV 2010). In both forest inventories, trees were sub-divided into three main tree-species groups: conifers, deciduous trees (except for oaks) and oaks. In addition, dead wood was classified into a total of four decomposition-level categories (BMELV 2010, BMVEL 2001).

For purposes of reporting pursuant to IPCC (2003), the applicable dead-wood-stock relationship between the 10 cm and 20 cm survey limits was determined from the data collected in the Inventurstudie. Under the assumption that that relationship was the same at the time of BWI 2, the dead-wood stocks from the 10 cm survey limit upward were estimated for the year 2002. The biomass of the dead wood stocks from BWI 2 (2002) and the Inventurstudie (2008), for the various relevant decomposition classes, was determined with the wood density figures pursuant to FRAVER et al (2002) for conifers, and with the wood density figures pursuant to MÜLLER-USING & BARTSCH (2009) for deciduous trees. To

calculate the wood density of deciduous wood, the dead-wood objects in the deciduous (other than oak) and oak tree-species groups were combined. The annual C-stock change in dead wood was calculated pursuant to Equation 23 (IPCC 2003, Equation 3.2.12). It amounts to 0.09375 MgC ha⁻¹ a⁻¹.

Equation 23

$$\Delta C_{FFDW} = \frac{A * (B_{t_2} - B_{t_1})}{T} CF$$

where:

ΔC_{FFDW} = Annual change in carbon stocks in dead wood, on forest land remaining forest land

A = Area of forest land remaining forest land

B_{t_1} = Dead-wood stocks at time t_1 for forest land remaining forest land

B_{t_2} = Dead-wood stocks at time t_2 (previous time) for forest land remaining forest land

$T=(t_2-t_1)$ = Time period between the two estimates

CF = Carbon conversion factor (standard value = 0.5)

7.2.4.2.2 New forest land

On new forest land (0-20 years), no creditable accumulation of dead wood takes place, since the dead-wood objects produced on such land tend to have diameters smaller than 10 cm. Pursuant to the guidelines for climate reporting, the survey threshold for dead-wood objects is a diameter of at least 10 cm. The BWI 2 data indicate that the mean BHD of a 20-year-old plantation is no more than 10 cm, throughout all tree species. For this reason, for the entire report period, no dead wood is reported on new forest land, and NO (not occurring) is entered at the corresponding locations in the CRF tables.

7.2.4.3 Forest-floor litter

7.2.4.3.1 Forest land remaining forest land

The calculation of C-stock changes in the soil and in forest-floor litter is based on data from national forest-soil surveys (BZE I and BZE II) and on the BioSoil inventory data. It was not possible to prove carbon-stock changes in the period from 1990 (BZE I) to 2006 (BZE II / BioSoil) (cf. Chapter 7.2.4.3.4); for this reason, a change of 0 MgC ha⁻¹ a⁻¹ is assumed. A similar approach is taken for the period 2007 to 2009. Therefore, NO (not occurring) is entered at the corresponding locations in the CRF tables.

7.2.4.3.2 New forest land

Carbon stocks in forest litter were calculated on the basis of status data from the BZE II and BioSoil surveys. According to those calculations, the mean carbon stocks in litter, in sample year 2006, amount to 19.8 MgC ha⁻¹ (cf. Chapter 7.2.4.3.3). Those carbon stocks in litter are also used as the basis for calculating stocks on afforestation areas in the period 1990 to 2009.

Ground cover (litter) forms only gradually in new forest areas. It was assumed that it takes 40 years for mean carbon stocks of 19.8 MgC ha⁻¹ to form in litter. Annual carbon-stocks additions in litter of 0.5 MgC ha⁻¹ a⁻¹ are assumed. Those values are confirmed by standard values for carbon storage in forest-floor litter, and by standard values for the time periods required for a new balance to form, pursuant to the Good Practice Guidance of the IPCC (2006) and PAUL et al. (2009).

7.2.4.3.3 Derivation of litter carbon stocks in 1990 (BZE I) and 2006 (BZE II/BioSoil)

Sampling of litter was carried out by taking mixed samples, at satellite points, using sampling frames of various sizes. The litter was considered to comprise all dead organic cover with a fraction < 20 mm. For some 80 % of points, the fraction > 20 mm was also included in the litter sample. Organic carbon concentrations in the litter were measured via comparable methods (KÖNIG et al. 2005). In the process, total (C_{ges}) is assumed to be equal to organic carbon (C_{org}), i.e. $[C_{ges}] = [C_{org}]$. In each case, the carbon stocks in litter are calculated from the area of the sampling frame, and from the weight and organic concentration of the relevant litter.

All points available from the BZE II and BioSoil surveys, along with information as to the forest type concerned in each case, entered into calculation of litter carbon stocks. All values that were either smaller or larger than twice the standard deviation ($\bar{x} \pm 2 \sigma$) were considered to be outliers and were deleted. From the values of the remaining data points for the BZE I ($n = 1486$) and BZE II / BioSoil ($n = 671$) surveys, it was possible to calculate carbon stocks separately for deciduous, coniferous and mixed forest (cf. Table 198).

The mean carbon stocks in the sample were 19.8 Mg ha^{-1} , with a standard error of 0.6 Mg ha^{-1} . That value, a country-specific value for forest-floor litter, replaces the recommended standard value from IPCC (2003) as the basis for calculating CO_2 emissions from litter in connection with deforestation (cf. Chapter 11.3.1.1.3) and carbon storage in litter in connection with afforestation (cf. Chapter 7.2.4.3.2).

Table 198: Carbon stocks in litter in German forests, as determined in the BZE I and BZE II / BioSoil inventories, along with the pertinent standard error

Forest type	Carbon stocks (BZE I) [Mg/ha]	Carbon stocks (BZE II/BioSoil) [Mg/ha]
Deciduous forest	12.6 ± 0.8	12.1 ± 1.2
Mixed forest	18.9 ± 1.4	18.3 ± 2.1
Coniferous forest	26.2 ± 0.6	27.1 ± 1.1

7.2.4.3.4 Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II/Biosoil)

Calculation of carbon-stock changes in litter was limited to the total of only 718 sampling points at which it was possible to compare the two inventories. That group of sampling points was treated as a paired group of sampling points. The difference between the stocks was defined, and then tested with a two-sided t-test for paired samples. The resulting differences did not deviate significantly from zero. The average change amounted to $0.04 \text{ MgC ha}^{-1} \text{ a}^{-1}$, with a standard error of $\pm 0.03 \text{ MgC ha}^{-1} \text{ a}^{-1}$.

7.2.4.4 Mineral soils

7.2.4.4.1 Forest land remaining forest land

Carbon stocks, and carbon-stock changes, in mineral soils were extrapolated on the basis of the national forest-soil surveys (BZE I and BZE II) and on the BioSoil inventory data (cf. 7.2.2.2). The data from the second soil survey are currently being evaluated. With a view to showing that the soil is not a C source, changes in mineral soils were calculated, with the existing data, for both inventories. The relevant methods are described in detail in chapters

7.2.4.4.3 and 7.2.4.4.4. From the results, which are still provisional, and which include only part of the relevant data, a C source is ruled out. Because the results are provisional, they have not been included in the CRF tables with respect to category 5.A.1 (forest land remaining forest land).

7.2.4.4.2 *New forest land*

The carbon-stock changes in mineral soils of new forest land were calculated by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTI-AK; cf. 7.3.4.2). The calculated emission factors (implied emission factors), which are summarised in Table 205, are oriented to annual carbon-stock changes in mineral soils of defined land-use categories that change into forest over a change period of 20 years.

Table 199: Emission factors for mineral soils in land-use categories involving conversion to forest land, for the year 2009

Land-use change	Emission factor [MgC ha ⁻¹ a ⁻¹]
Cropland converted to forest land	0.53365
Grassland converted to forest land	0
Wetlands converted to forest land	-0.03097
Settlements converted to forest land	0

7.2.4.4.3 *Derivation of carbon stocks and carbon-stock changes*

Mineral soil was sampled at depths of relevance for the national inventory report; at most BZE points, this involved depth ranges of 0-5 cm, 5-10 cm and 10-30 cm. In a few cases, samples were taken on a horizon basis. In the BioSoil inventory, samples were taken at depth ranges of 0-5 cm, 5-10 cm, 10-20 cm and 20-40 cm.

In sampling, data was collected on the dry density of fine soil (TRD_{fb}) and the concentration of organic carbon (C_{org}). The dry density of fine soil was determined via volume-adapted sampling, for different depth ranges; to some extent, estimated values based on soil profiles were used (WOLFF & RIEK 1996, WELLBROCK et al. 2006). Where dry-density information is lacking, existing relevant values from other inventories have been used. This has also been the case for data on coarse-soil fractions, which are needed for calculation of TRD_{fb} and fine-soil stocks.

Total carbon (C_{ges}) was determined via comparable methods (König et al. 2005). In soils containing carbonate, the organic carbon concentration (C_{org}) in fine soils was measured, via a procedure that also took account of concentrations of inorganic carbon (C_{inorg}) ($[C_{org}] = [C_{ges}] - [C_{inorg}]$). In soils that do not contain carbonate, the relationship $[C_{org}] = [C_{ges}]$ applies.

The carbon stocks were calculated from the stocks for the individual depth ranges. To that end, it was necessary first to translate horizon-based data into depth-range sections. This was accomplished, in each case, by calculating the carbon stocks in a given depth-range section, with stocks weighted in accordance with the thicknesses of overlapping sections and their carbon stocks. This was also carried out for the different depth-range section, 20-40 cm, used by the BioSoil inventory.

For calculation of carbon stocks, and their changes between the two inventory times, strata were formed, to permit use of an area-oriented approach. The basis for formation of area-relevant strata consisted of the 72 legend units used in the national soil map

"Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000" (BÜK 1000). That source describes the main soil types, and source rocks for soil formation, pursuant to the German soil system (AG BODEN 1994) and FAO legend (FAO-UNESCO 1990). Since the classes concerned differed in the number of sampling points they contained, the various main soil units were aggregated into new main soil units. This increased the basic totality for each class, thereby increasing the pertinent statistical significance. The classes formed were oriented to comparable soil types, to substrate type and source rock and to soil type and lime content. All in all, 24 new main soil units, with their pertinent source rocks, were then available for area-based evaluation (cf. Table 200).

Table 200: Combined legend units on the basis of the BÜK 1000 soil map

Abb.	Main soil units, by substrate type, soil type and lime content
1	Regosol / podsol-regosol / loose syrosem / brown-earth podsol / podsol brown earth composed of dry, nutrient-poor sands
2	Alluvial soil / gley from loamy to clayey alluvial sediments
3	Alluvial soil / gley from sandy to loamy, partly calcareous high-flood and alluvial sediments
4	Brown earth / para-brown earths / pararendzina from silty-loamy covering layers on glacial gravel deposits or sandy terrace deposits
5	Podsol / podsol – brown earths / brown-earth - podsol / gley-podsol from sandy riverine and terrace deposits
6	Para-brown earth / pale earth / pseudogley – para-brown earth from boulder clay
7	Para-brown earth - chernosem soil / para-brown earth / pseudogley / brown earth / pararendzina from loamy-sandy, calcareous moraine deposits
8	Pseudogley / pseudogley-chernosem from boulder clay, with a loamy-sandy covering layer
9	Podsol – para-brown earth / podsol – pale earth / pale earth / brown earth from sandy covering layers overlying boulder clay
10	Pararendzina / regosol / striated para-brown earth in tight alternations of sandy-to-loamy end-moraine formations
11	Podsolated pseudogley – brown earth / pseudogley – pale earth / brown earth – pseudogley / podsol-pseudogley from sandy covering layers over boulder clay
12	Brown earth / pseudogley from calcareous, loamy-sandy-gravelly, loess-bearing moraine deposits
13	Para-brown earth / pale earth / pseudogley / from loess-bearing weathering products of various silicate rocks
14	Brown earth / para-brown earth / pale earth from sand-bearing loess or loess-loam
15	Brown earth / pseudogley / para-brown earth from loess or loess-loam
16	Rendzina / brown earth – rendzina / brown earth / pararendzina from calcareous, marl and dolomite rocks alternating with terra fusca – brown earth / terra fusca – para-brown earth from silty-clayey redeposited products of limestone weathering
17	Pelosol – brown earth / pelosol-pseudogley from weathering products of marl and clay rocks
18	Brown earth / brown earth – pseudogley from acidic to alkiline magmatic and metamorphic rock or alkaline tuffs, in part with loess-bearing weathering products
19	Brown earth / podsolic brown earth / podsol – brown earth from acidic magmatic and metamorphic rock or from siltstone, sandstone and claystone
20	Podsolic brown earth from loess-bearing covering layers over sandstone and quartzite
21	Pseudogley / podsol-pseudogley from loess-bearing gritty cover sediments mixed with loam overlying sandstone and quartzite
22	Brown earth / podsol brown earth / brown earth - rendzina / para-brown earth alternating tightly with slate, greywacke and limestone, and loessic loam overlying various rocks
23	Rendzina / pararendzina / ranker / podsol – brown earth / pelosol – brown earth / para-brown earth / pseudogley alternating tightly with calcareous and marl rock; with sandstone, siltstone and claystone; and with loessic loam overlying various rocks
24	Soils of different alpine elevations, from limestone and dolomite, and from non-calcareous silicate rocks

A total of 1631 points from the BZE I survey, and 1096 points from the BZE II survey / BioSoil inventory, were used. For 603 points, the data were available as paired samples, i.e. samples in which it was possible to correlate each BZE I point with exactly one BZE II point or one BioSoil point. Once the carbon stocks for each main soil unit, and for the different inventory times, had been plotted against each other in a linear regression, it was possible to identify outliers via residual analysis. A relevant example is presented in Figure 50 (on the left). Studentised residuals were used to eliminate outliers that seemed inconsistent with the rest of the data (cf. Figure 50 (middle)). In addition, a "hat matrix" was generated, for identification

of "leverage" points that represent outliers within the independent variable (cf. Figure 50 (right)) (WEISBERG 2005).

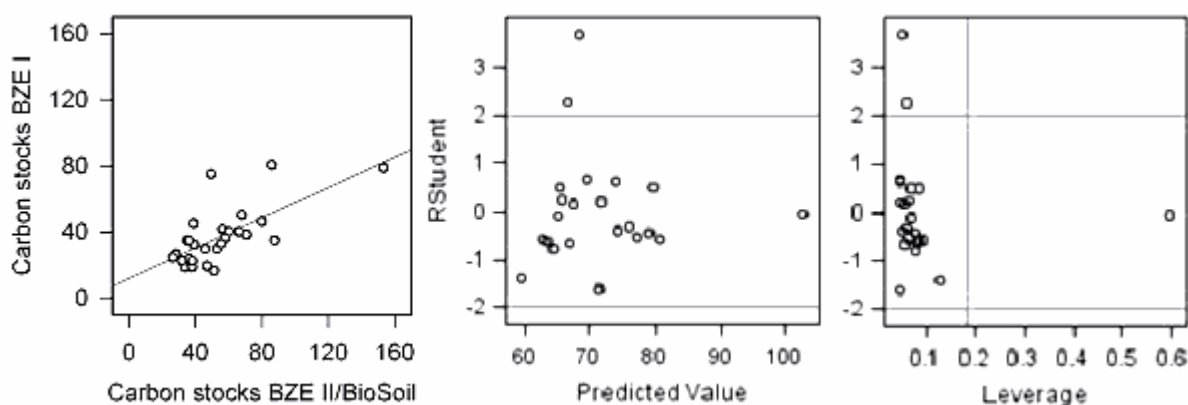


Figure 50: Regression between carbon stocks (0-30cm) as shown by BZE II / BioSoil data and the BZE I data (left), and outliers identified via residuals analysis with studentised residuals (middle) and "high-leverage" points (right), with regard to the example of the new main soil unit podsol – para-brown earth / podsol – pale earth / pale earth / brown earth from sandy covering layers overlying boulder clay.

Some German Länder had shifted the grid between the BZE I and BZE II surveys, and a total of 280 points were left as unpaired samples as a result. Carbon stocks for these points were calculated via formation of mean values for each main soil unit. Outliers for each class were detected via double standard deviation ($\bar{x} \pm 2\sigma$) and then removed. Then, the mean carbon stocks for each main soil unit were correlated with the relevant annual differences. After elimination of the outliers, a total of 219 points from the BZE I survey, and 274 points from the BZE II survey / BioSoil inventory, were left.

To make it possible to calculate carbon-stock changes on an area basis, the mean rates of carbon-stock changes for the new main soil units were applied to Germany's forest areas. In each case, it proved possible to correlate a forest area with the mean carbon-stock change for a main soil unit. That, in turn, made it possible to calculate the average annual change in organic carbon for Germany, taking account of existing forest areas.

7.2.4.4.4 Results of derivation of carbon stocks and carbon-stock changes

On the basis of the area-based approach, the carbon stocks in mineral soil, to a depth of 30 cm, and for Germany, amounted to 59.4 Mg ha^{-1} at the time of the BZE I inventory, and to 68.0 Mg ha^{-1} at the time of the BZE II / BioSoil inventories. Those figures translated into annual increases of 0.5 MgC ha^{-1} . Both the rate of change and the total stocks lie within a range that other authors have estimated for central Europe. Estimates for annual carbon storage in the root zone range from $0.1 \text{ Mg ha}^{-1} \text{ a}^{-1}$ (NABUURS & SCHELHAAS 2002) to $0.9 \text{ Mg ha}^{-1} \text{ a}^{-1}$ (SCHULZE et al. 2000). Most of the values given in the literature are based on sample extrapolations, and they take the soil's entire root zone into account (LISKI et al. 2002; DE VRIES et al. 2006). In comparison to those studies, the present effort was able to draw on considerably more measurement points, arrayed within a finer point grid. Those data represent a more valid sample, one that supports conclusions for Germany that are more reliable and that have a complete-coverage focus.

For nearly all main soil units, carbon stocks, broken down by classes, were estimated to be higher at the time of the BZE II / BioSoil surveys than they had been at the time of the BZE I

survey (cf. Table 201). In addition, carbon stocks were higher in soils with high clay content than they were in soils with high sand content. The reasons for this are discussed in, for example, SIX et al. (2002) and BARITZ et al. (2010). Evaluation of the time series between the BZE I and BZE II / BioSoil surveys shows greater annual changes in carbon stocks especially in sandy main soil units of the North German lowlands. For example, the annual rate of change in main soil units 1, 5, 9, 14 was over $1.0 \text{ MgC ha}^{-1} \text{ a}^{-1}$. PRIETZEL et al. (2006), on the other hand, refers to carbon sequestration of $0.2 \text{ Mg ha}^{-1} \text{ a}^{-1}$ in the upper 30 cm of sandy locations and of $0.4 \text{ Mg ha}^{-1} \text{ a}^{-1}$ on loamy locations. Smaller positive changes in carbon stocks, ranging between 0.2 and $0.7 \text{ Mg ha}^{-1} \text{ a}^{-1}$, were found in over half of all classes formed. On the other hand, classes 4, 7, 10, 12 and 16 showed either virtually no changes or some reduction of carbon stocks between the two inventory times. For nearly all remaining classes – except for the rather sandy north German soils, which had higher positive rates of carbon-stock changes – the entire range of soil types and of substrate was covered.

Table 201: Carbon stocks at the time of the BZE I survey and at the time of the BZE II survey, and annual rates of carbon-stock change, in the newly formed main soil units; and correlated forest areas

Abb.	Carbon stocks (BZE I) [MgC ha ⁻¹]			Carbon stocks (BZE II) [MgC ha ⁻¹]			Forest area [ha]	Rates of carbon- stock change [MgC ha ⁻¹ a ⁻¹]
	n	MW	SE	n	MW	SE		
1	95	33.8	1.9	100	49.5	2.4	986673	1.1
2	9	100.9	14.0	14	115.2	10.7	254865	1.0
3	30	63.1	7.2	32	71.7	6.4	163440	0.6
4	22	68.1	4.1	16	59.1	3.1	448317	-0.5
5	15	59.6	5.5	21	74.0	7.7	347526	1.1
6	14	51.4	9.9	14	66.1	8.2	503030	1.0
7	22	72.8	3.4	19	82.1	4.6	171513	0.1
8	8	60.4	6.0	14	68.8	6.0	255913	0.5
9	24	33.6	2.8	24	49.1	3.3	64559	1.1
10	4	31.9	3.8	4	33.4	4.4	276957	0.1
11	8	47.3	6.0	8	52.7	6.5	186452	0.4
12	5	74.8	3.7	8	62.0	6.3	239832	-0.6
13	33	56.3	2.9	24	64.6	2.8	91350	0.6
14	18	28.0	3.3	18	43.1	4.3	645929	1.1
15	23	62.3	3.5	28	67.0	2.5	105976	0.3
16	31	87.1	4.4	25	80.7	4.1	139403	-0.3
17	22	65.2	2.8	14	68.1	4.0	1042722	0.2
18	65	63.7	2.3	116	71.8	2.0	368595	0.5
19	73	63.3	2.5	49	70.9	3.3	835871	0.6
20	41	63.8	2.4	17	79.2	4.2	2158740	0.7
21	6	48.3	6.1	6	53.2	5.2	1038945	0.3
22	69	57.2	2.3	69	66.2	2.5	75185	0.6
23	9	56.7	6.6	15	72.6	6.3	82119	0.9
24	8	116.3	12.9	11	128.0	6.1	163752	0.6

(LBE = main soil units (Leitbodeneinheiten), n = number of soil samples, MW = mean value (Mittelwert), SE = standard error)

7.2.4.5 Organic soils

7.2.4.5.1 Forest land remaining forest land

The areas covered by organic soils were determined via a georeferencing procedure, with overlaying of BÜK 1000 and ATKIS data (cf. also Chapter 19.5.2.1.3). The carbon-stock

changes of organic soils were estimated with the aid of the IPCC (2003) values from Table 3.2.3. For this process, it is assumed that all organic sites are affected by drainage⁶⁴ and that the drainage is solely responsible for the changes. For organic forest soils, carbon emissions of $0.68 \text{ MgC ha}^{-1} \text{ a}^{-1}$, and nitrous oxide (N_2O) emissions of $0.6 \text{ kg ha}^{-1} \text{ a}^{-1}$, were calculated.

7.2.4.5.2 New forest land

For new forest land, as for forest land remaining forest land, it is assumed that all afforested areas are drained (cf. Chapter 7.2.4.5.1). The relevant C emissions amount to $0.68 \text{ MgC ha}^{-1} \text{ a}^{-1}$. The same annual change was also assumed for the years 1990 to 2009.

7.2.4.6 Other greenhouse-gas emissions from forests

Forests in Germany are not normally given nitrogen fertilisers. In CRF Table 5(I), therefore, this activity has been marked "NO" (not occurring).

7.2.4.6.1 Liming

Figures for CO_2 emissions from liming of forest soils are provided in category 5.G. (Other). They range from 162.37 Gg a^{-1} (1992) to 52.35 Gg a^{-1} (2008), and show a decreasing trend. For 2009, the relevant CO_2 emissions amounted to 65.42 Gg a^{-1} .

The liming data was derived from the total fertilisers calculation. It describes producers' and importers' deliveries to wholesalers and end users (FEDERAL STATISTICAL OFFICE, 1990). For the calculation, the amount of fertiliser applied was assumed to be the same as the amount sold. The relevant emissions were derived using equation 3.3.6 from IPCC GPG-LULUCF (2003: p. 3.80). Further pertinent information is presented in chapters 7.3.4 and 19.5.2.4.

7.2.4.6.2 Forest fires

While in other countries "prescribed burning" is an accepted method for clearing land or for managing ecosystems, no prescribed/controlled burning of biomass is carried out in Germany's managed forests. In keeping with Germany's climatic situation, and with measures taken in Germany to prevent forest fires, such fires tend to occur rather seldomly. This conclusion is confirmed by relevant forest-fire statistics (BLE, 2010) and their data on areas affected by forest fire (cf. Figure 51). The mean area affected annually by forest fire, in the period 1990 – 2009, was 903 ha. High summer temperatures, such as those seen in 1996 and 2003, tend to increase forest-fire damage. In 1992, the burned forest area reached a rather unusual extent of about 4900 ha, as a result of an extremely warm summer.

⁶⁴ Since no figures are available relative to the areas covered by undrained organic soils, a conservative approach is taken whereby all of the organic soil is assumed to be drained.

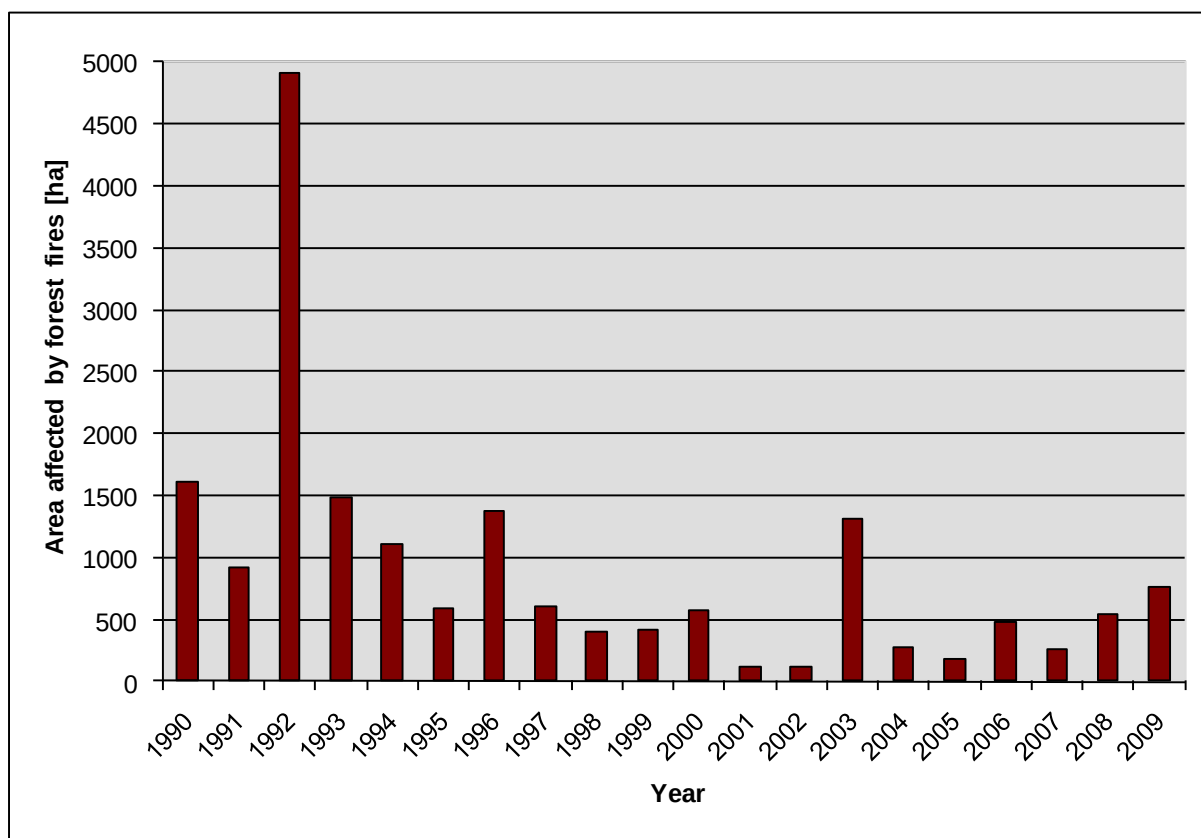


Figure 51: Areas affected by wildfires between 1990 and 2009 (pursuant to BLE, 2010)

In forest fires ("wildfires"), both CO₂ and other greenhouse gases (CO, CH₄, N₂O and NO_x) are released. The CO₂ emissions resulting from biomass combustion have already been taken into account as part of changes of biomass stocks (CRF Sector 5.A.1 Forest land remaining forest land), via the "stock-change method". For this reason, they are listed as "IE" (included elsewhere). Emissions of other greenhouse gases were calculated with Equation 24 (IPCC 2003, Equation 3.2.20).

Equation 24

$$L_{fire} = A * B * C * D * 10^{-6}$$

where:

- L_{fire} = Quantity of greenhouse gas released via fire [t]
- A = Wildfire burn area [ha]
- B = Mass of fuel present on the relevant site (biomass) [kgTM ha⁻¹]
- C = Combustion efficiency
- D = Emission factor [g(kgTM)⁻¹]

The data on areas affected by forest fires in the period 1990 to 2009 have been taken from the forest-fire statistics maintained by the Federal Agency for Agriculture and Food (BLE; Waldbrandstatistik – BLE 2009). For the period between 1990 and 2009, the mean above-ground biomass was derived via linear extrapolation and interpolation, using the data of the BWI 2 (Bundeswaldinventur (National Forest Inventory) 2) and the Inventurstudie 2008 inventory study. Pursuant to the expert assessment carried out by KÖNIG (2007), 80 % of the forest fires in Germany remain on the ground surface and 20 % rise into tree crowns. In accordance with Table 3A.1.12 (IPCC 2003), a combustion efficiency (mass loss via direct combustion) of 0.15 was used for fires remaining on the ground surface, and an efficiency of

0.45 was used for fires rising into tree crowns. The emission factors for CH₄ and N₂O were taken from Table 3A.1.16 (IPCC 2003).

Germany suffers relatively little forest-fire damage in terms of burn area, and thus the relevant CH₄ and N₂O gas emissions are low. With the exception of the emissions in 1992, the CH₄ emissions range from 34 Mg to 433 Mg, and the N₂O emissions range from 0.5 Mg to 6.7 Mg. These emissions levels were exceeded in 1992 (CH₄: 1.33 Gg; N₂O: 20.7 Gg), which had an extremely warm summer that was responsible for a larger-than-average burn area, amounting to some 4,908 ha. The complete time series for greenhouse gases resulting from wildfires is shown in Table 202.

Table 202: Greenhouse gases emitted as a result of wildfires, in the period 1990-2009

Year	Above-ground biomass [Mg ha ⁻¹]	Wildfire burn area [ha]	Emitted gases [Mg]	
			CH ₄	N ₂ O
1990	180.7	1,606	433	6.7
1991	181.4	920	249	3.9
1992	182.1	4,908	1,333	20.7
1993	182.9	1,493	407	6.3
1994	183.6	1,114	305	4.7
1995	184.4	592	163	2.5
1996	185.1	1,381	381	5.9
1997	185.9	599	166	2.6
1998	186.6	397	110	1.7
1999	187.4	415	116	1.8
2000	188.1	581	163	2.5
2001	188.8	122	34	0.5
2002	189.6	122	34	0.5
2003	190.3	1,315	373	5.8
2004	191.1	274	78	1.2
2005	191.8	183	52	0.8
2006	192.6	482	138	2.1
2007	193.3	256	74	1.1
2008	194.1	539	156	2.4
2009	194.8	757	220	3.4

7.2.4.6.3 Drainage

No area data are available with regard to drainage of mineral soils. It may be assumed that no drainage occurs on mineral soils. For this reason, the entry for N₂O emissions from mineral soils is "NO" (not occurring).

Information about drainage of organic soils, with regard to both CO₂ and N₂O, is provided in Chapter 7.2.4.5.

7.2.4.6.4 Land-use changes from forest land to cropland

The vTI's Institute of Agricultural Climate Research (vTI-AK) is responsible for determination of N₂O emissions in connection with land-use changes resulting in cropland. The relevant procedure is described in Chapter 19.5.2.5. Table 203 shows the N₂O emissions for conversion of forest land to cropland, for mineral and organic soils.

Table 203: N₂O emissions from conversion of forest land to cropland

Time period [year]	N ₂ O emissions [kg ha ⁻¹ a ⁻¹]
1990-2005	29.39
2006	29.90
2007	31.90
2008	32.21
2009	32.85

7.2.5 Uncertainties and time-series consistency (5.A)

In calculation of carbon stocks, various errors occur, mostly as a result of uncertainties. Errors are derived using practical approaches, and thus such derivation provides only an approximation of the actual errors at work. The calculation does not take account of every possible error source (deviation of allometry, model errors in standing-timber calculation, measurement errors). Correlations between individual terms were neglected.

With the available data, the following error sources can be quantified:

- Uncertainties in estimation of areas affected by land-use changes
- Uncertainties in estimation of above-ground and below-ground biomass
- Uncertainties in estimation pertaining to forest-floor litter and mineral soils

With regard to the uncertainties in the carbon-conversion factor, we call attention to Chapter 7.2.4.1.6. A comprehensive statistical study of the measurement errors in the Inventurstudie 2008 found that such errors can be neglected (DUNGER et al. 2010c).

When aggregated, error estimates (U) for values ($1, \dots, i, \dots, I$) propagate themselves in two different ways. When two values are added or subtracted, the error propagation is additive (cf. Equation 25):

Equation 25

$$U = \frac{\sqrt{\sum_i (U_i x_i)^2}}{\sum_i x_i}$$

where:

- U = Total uncertainty
- U_i = Uncertainty for target value i
- x_i = Quantity of target value i

On the other hand, when two values are multiplied or divided, the errors for the two values propagate themselves multiplicatively (cf. Equation 26)

Equation 26

$$U = \sqrt{\sum_i (U_i)^2}$$

7.2.5.1 Uncertainties in estimation of areas affected by land-use changes

Relevant areas, in keeping with separate LULUCF categories, are derived separately for the new German Länder and the old German Länder. For the old German Länder, in the BWI 1 and BWI 2 surveys, land-use-category data, at each relevant time, were collected for each cluster corner on both forest land and non-forest land. On the basis of those samples, it has

been possible to determine land-use changes on the basis of the differentiated LULUCF categories, and with error estimation (cf. Table 165).

For the new German Länder, the results of the project "GSE FM-INT" (GSE 2003, GSE 2006, GSE 2007, GSE 2009) were available for the period 1990 to 2005. With the help of analyses of satellite-based remote-sensing data, change analyses with regard to land cover / land use were carried out and verified with accepted statistical methods. The results for the individual Länder were then aggregated. The area-estimation errors were weighted by area and then summed separately by LULUCF classes (cf. Table 204).

Table 204: Sampling error (SE) in area estimation for LULUCF classes, between 1987 and 2002 (nd = not defined⁶⁵)

	Old German Länder	New German Länder	Germany
LULUCF classes	SE [%]	SE [%]	SE [%]
Forest land remaining forest land	0.93	1.12	0.74
Forest land converted to cropland	26.51	1.98	24.93
Forest land converted to grassland	14.18	2.08	13.48
Forest land converted to settlements	11.14	7.24	9.99
Forest land converted to wetlands	24.85	11.18	21.18
Forest land converted to other land	nd	nd	nd
Cropland converted to forest land	13.59	2.91	12.16
Grassland converted to forest land	8.61	3.13	6.85
Settlements converted to forest land	13.32	3.86	12.49
Wetlands converted to forest land	15.92	8.25	15.37
Other land converted to forest land	nd	nd	nd
KP afforestation	5.98	2.30	5.18
KP deforestation	7.92	4.87	7.21

From the Inventurstudie 2008, it was possible to make land-use-change estimates, for the period 2002 to 2008, solely for the classes *forest land remaining forest land* and *KP deforestation* (cf. Table 205). The error for the class *KP deforestation* was transferred to the land-use categories involving conversion of forest land into a different land-use category. The area changes in those land-use categories in which afforestation took place were linearly extrapolated from the earlier period through the year 2009.

Table 205: Sampling error (SE) in area estimation for LULUCF classes between 2002 and 2008

	Old German Länder	New German Länder	Germany
LULUCF category	SE [%]	SE [%]	SE [%]
Forest land remaining forest land	2.06	3.46	1.77
KP deforestation	27.36	44.69	23.72

7.2.5.2 Uncertainties in estimation of above-ground and below-ground biomass

7.2.5.2.1 Conversion of standing-timber volume into tree-wood volume

The natural variability of above-ground tree allometry has not been included. This error cannot be calculated, since the original figures of GRUNDNER & SCHWAPPACH (1952) are not available. The trees with which they obtained their figures grew between 1750 and 1900, and it is not possible to identify relevant allometric differences resulting from changes in environmental conditions, and in management, that have occurred since then. The tables contain only already smoothed values, and thus the actual variance is systematically underestimated. This error analysis thus can only calculate the error for conversion of standing-timber volume into tree wood volume. The standard deviation of the residuals of the models is shown in Table 206.

⁶⁵ There are no areas in the land-use category *Other Land*

Table 206: Relative standard error of volume-expansion models

Model		Mean (tree wood)	Standard deviation (residuals)	Relative standard error [%]
Oak		4.69	0.19	4.10
Birch		0.69	0.01	1.09
Alder		0.69	0.01	0.91
Beech	Age to 60	0.36	0.02	5.47
Beech	Age 61 to 100	1.25	0.05	4.06
Beech	Age at least 101	2.67	0.07	2.57
Spruce	Age to 60	0.45	0.05	11.28
Spruce	Age at least 61	3.60	0.16	4.55
Pine	Age to 80	0.60	0.02	3.08
Pine	Age at least 81	2.11	0.07	3.27
Fir	Age to 80	0.89	0.06	6.22
Fir	Age 81 to 121	3.53	0.26	7.50
Fir	Age at least 121	6.98	0.62	8.94
Larch		3.21	0.07	2.22

Table 207 shows the uncertainties that arise in the volume expansion. It includes only the uncertainties for cases in which C stocks can be directly estimated.

Table 207: Uncertainties arising in the volume expansion

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest land remaining forest land	2.99	2.84	2.18	2.90	1.70	1.70	1.76	1.71
Forest land converted to cropland	2.12	–	–	–	–	–	–	–
Forest land converted to grassland	2.81	–	–	–	–	–	–	–
Forest land converted to settlements	2.14	–	–	–	–	–	–	–
Forest land converted to wetlands	3.08	–	–	–	–	–	–	–
Forest land converted to other land	–	–	–	–	–	–	–	–
Cropland converted to forest land	–	2.11	–	–	–	–	–	–
Grassland converted to forest land	–	2.07	–	–	–	–	–	–
Settlements converted to forest land	–	2.00	–	–	–	–	–	–
Wetlands converted to forest land	–	1.04	–	–	–	–	–	–
Other land converted to forest land	–	–	–	–	–	–	–	–
KP Afforestation	–	2.70	–	–	–	–	–	–
KP deforestation	2.14	2.45	–	–	2.23	–	1.93	–

7.2.5.2.2 Bulk densities applying to specific tree-species groups

Bulk densities differ from species to species and can fluctuate within one and the same tree. KOLLMANN (1982) gives variation ranges for raw densities. With the help of these variation ranges, the standard deviation can be estimated pursuant to SACHS (1984). For left-leaning and right-leaning distributions (approximations of triangular distributions) of bulk densities, distributions that are actually seen in trees (BOSSHARD 1984; KOLLMANN 1982), the range is divided by 4.2. It was not possible to take account of the error arising in conversion of raw

density into bulk density, since no relevant data are available. In this case, it was assumed that this error would not affect the bulk-density range.

Table 208: Relative standard error of bulk-density estimates

Tree species	Mean raw density	Minimum raw density	Maximum raw density	Standard error	
				estimated	se [%]
Beech	0.68	0.49	0.88	0.09	13.66
Douglas fir	0.47	0.32	0.73	0.10	20.77
Oak	0.65	0.39	0.93	0.13	19.78
Larch	0.55	0.40	0.82	0.10	18.18
Ash (ALH)	0.65	0.41	0.82	0.10	15.02
Spruce	0.43	0.30	0.64	0.08	18.83
Pine	0.49	0.30	0.86	0.13	27.21
Poplar (ALN)	0.41	0.37	0.52	0.04	8.71
Fir	0.41	0.32	0.71	0.09	22.65

For secondary tree-species groups that are relatively unimportant in terms of numbers, including deciduous trees with high life expectancies (4.4 % of total standing-timber volume) and deciduous trees with low life expectancies (5.2 %), the values for ash and poplar were used. Table 209 shows the uncertainties that arise in the volume expansion. It includes only the uncertainties for cases in which C stocks can be directly estimated.

Table 209: Uncertainties arising in connection with use of bulk densities

LULUCF classes	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest land remaining forest land	9.19	8.63	8.16	13.87	12.31	12.41	7.14	6.86
Forest land converted to cropland	13.70	–	–	–	–	–	–	–
Forest land converted to grassland	8.65	–	–	–	–	–	–	–
Forest land converted to settlements	7.92	–	–	–	–	–	–	–
Forest land converted to wetlands	24.49	–	–	–	–	–	–	–
Forest land converted to other land	–	–	–	–	–	–	–	–
Cropland converted to forest land	–	8.05	–	–	–	–	–	–
Grassland converted to forest land	–	7.76	–	–	–	–	–	–
Settlements converted to forest land	–	6.83	–	–	–	–	–	–
Wetlands converted to forest land	–	6.65	–	–	–	–	–	–
Other land converted to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	6.96	–	–	–	–	–	–
KP deforestation	8.21	9.23	–	–	24.46	–	8.93	–

7.2.5.2.3 Derivation of below-ground biomass

The only available source for the standard errors for the root-biomass calculation was the tables pursuant to IPCC GPG-LULUCF (2003) (cf. Table 197). That source also uses quantity-weighted error extrapolation. To carry out error propagation by sums (IPCC, 2000: Equation 6.3), the sums of the above-ground mass calculations were computed for each stratum of the table. This made it possible to derive the total errors for conifers, oak and other deciduous trees (broadleaves). Table 210 shows the results – the values for the state in which it was possible to estimate C stocks directly.

Table 210: Uncertainties arising in use of root/shoot relationships

LULUCF classes	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest land remaining forest land	25.37	23.86	23.1	–	26.24	26.13	19.15	18.48
Forest land converted to cropland	32.36	–	–	–	–	–	–	–
Forest land converted to grassland	24.19	–	–	–	–	–	–	–
Forest land converted to settlements	22.43	–	–	–	–	–	–	–
Forest land converted to wetlands	32.34	–	–	–	–	–	–	–
Forest land converted to other land	–	–	–	–	–	–	–	–
Cropland converted to forest land	–	29.27	–	–	–	–	–	–
Grassland converted to forest land	–	26.61	–	–	–	–	–	–
Settlements converted to forest land	–	25.24	–	–	–	–	–	–
Wetlands converted to forest land	–	17.95	–	–	–	–	–	–
Other land converted to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	24.79	–	–	–	–	–	–
KP deforestation	23.09	22.51	–	–	35.27	–	19.20	–

An advantage of the IPCC root-biomass calculation is that it also yields the standard error for the estimation – in contrast to other methods, such as those presented in the studies of DIETER & ELSASSER (2002). The values entered into the CRF tables were derived pursuant to IPCC (2003).

7.2.5.2.4 Sampling error

The National Forest Inventory uses cluster sampling. Rather than a basic totality of samples, it includes only a random set of samples. The sampling elements themselves, as well as the mean and total values estimated on the basis of the sampling elements chosen, are subject to variance. The variance can serve as a tool for assessing the precision of the estimated target values. The variance of a measured value in a stratum l is estimated via the following relationship:

Equation 27

$$v\left(\hat{\bar{Y}}_l\right) = \frac{1}{c_l(c_l - 1)} \sum_{c_l=1}^{C_l} \left(\frac{M_{l,c}}{E\langle M_{l,c} \rangle}\right)^2 (Y_{l,c} - \hat{\bar{Y}}_l)^2$$

where:

v	= Variance
Y	= Target value
c	= Number of clusters
E	= Expected value
M	= Number of corners per cluster

The variance of the overall mean, throughout all strata, is defined as follows:

Equation 28

$$v\left\langle \hat{\bar{Y}}_{st} \right\rangle = \sum_{l=1}^L \left(\frac{\lambda(U_l)}{\lambda(U)} \right)^2 v\left\langle \hat{\bar{Y}}_l \right\rangle \approx \sum_{l=1}^L \left(\frac{n_l}{n} \right)^2 v\left\langle \hat{\bar{Y}}_l \right\rangle$$

where

$$n = \sum_{l=1}^L n_l = \sum_{l=1}^L c_l E\left\langle M_{l,c} \right\rangle = \sum_{c_l=1}^{C_l} M_{l,c}$$

The estimated variance of the change $v\left\langle \hat{\bar{G}}_l \right\rangle$ between two inventories whose sampling elements were repeatedly surveyed is calculated as follows:

Equation 29

$$v\left\langle \hat{\bar{G}}_l \right\rangle = v\left\langle \hat{\bar{Y}}_l^{(2)} \right\rangle + v\left\langle \hat{\bar{Y}}_l^{(1)} \right\rangle - 2r_{y^2y^1} \sqrt{v\left\langle \hat{\bar{Y}}_l^{(2)} \right\rangle} \sqrt{v\left\langle \hat{\bar{Y}}_l^{(1)} \right\rangle}$$

With $r_{y^2y^1} = \frac{s_{y^2y^1}}{s_{y^2} s_{y^1}}$ as a correlation coefficient and:

Equation 30

$$s_{y^2y^1} = \frac{1}{c_l(c_l - 1)} \sum_{c_l=1}^{C_l} \left(\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle} \right)^2 (Y_{lc}^{(2)} - \hat{\bar{Y}}_l^{(2)})(Y_{lc}^{(1)} - \hat{\bar{Y}}_l^{(1)})$$

The variance of the area-based mean (ratio estimator) $v\left\langle \hat{\bar{R}}_{st} \right\rangle$ from $\hat{\bar{Y}}_{st} / \hat{\bar{X}}_{st}$ is estimated as follows:

Equation 31

$$v\left\langle \hat{\bar{R}}_{st} \right\rangle = \frac{1}{(\hat{\bar{X}}_{st})^2} \sum_{l=1}^L w_l^2 \frac{\sum_{c_l=1}^{C_l} \left(\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle} \right)^2 (y_{lc} - \hat{R}_{st} x_{lc})^2}{c_l(c_l - 1)}$$

where:

w_l = Weight of stratum l
 X_{st} = Target value

The variance in the change of a ratio estimator ($v\left\langle \hat{\bar{G}}_{Rst} \right\rangle$) is defined as follows:

Equation 32

$$v\left\langle \hat{\bar{G}}_{Rst} \right\rangle = v\left\langle \hat{\bar{R}}_{st}^{(2)} \right\rangle + v\left\langle \hat{\bar{R}}_{st}^{(1)} \right\rangle - 2\text{cov}\left\langle \hat{\bar{R}}_{st}^{(2)}, \hat{\bar{R}}_{st}^{(1)} \right\rangle$$

where:

$$\text{cov}\left(\hat{R}_{st}^{(2)}, \hat{R}_{st}^{(1)}\right) = \frac{1}{\hat{X}_{st}^{(2)} \hat{X}_{st}^{(1)}} \sum_{l=1}^L \left(\frac{\lambda(\mathbf{U}_l)}{\lambda(\mathbf{U})} \right)^2 \frac{1}{n_{2,l}(n_{2,l}-1)}$$

$$\sum_{x \in F_1 \cap S_2} \left(\frac{M(x)}{E(M(x))} \right)^2 \left(d_c^{(2)}(x) - \hat{d}_l^{(2)} \right) \left(d_c^{(1)}(x) - \hat{d}_l^{(1)} \right)$$

and

$$d_c^{(2)}(x) = (Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x))$$

and

$$\hat{d}_l^{(2)} = \frac{1}{n_{2,l}} \sum_{x \in F_1 \cap S_2} (Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x))$$

with $d_c^{(1)}(x)$ and $\hat{d}_l^{(1)}$ having the corresponding values.

Therefore, the estimation procedures presented here can be used to calculate, on the basis of the National Forest Inventory, the precision of biomass estimates for each LULUCF category in which such estimates are made.

Since C-stock calculation for the new German Länder was possible only with the method pursuant to BURSCHEL et al. 1993, taking account of data in the publication: "Der Wald in den neuen Bundesländern" ("The Forest in the New German Länder", BMELF, 1994), the procedure for the old German Länder can be adopted here only partially. On p. 9 of that publication, the following statement about errors relative to stocks is made: "The stocks on the sub-area were determined, in the framework of the forest-establishment procedure, with a mean standard error of ± 12.5 %." Assuming that that error has had a systematic impact on extrapolation, a value of ± 12.5 % may be assumed for the relevant tree-species groups.

Table 211: Sampling error for above-ground biomass

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest land remaining forest land	1.07	1.04	2.34	12.50	3.91	3.84	2.01	2.00
Forest land converted to cropland	55.12	–	–	–	–	–	–	–
Forest land converted to grassland	45.42	–	–	–	–	–	–	–
Forest land converted to settlements	18.73	–	–	–	–	–	–	–
Forest land converted to wetlands	69.85	–	–	–	–	–	–	–
Forest land converted to other land	–	–	–	–	–	–	–	–
Cropland converted to forest land	–	26.46	–	–	–	–	–	–
Grassland converted to forest land	–	15.37	–	–	–	–	–	–
Settlements converted to forest land	–	20.9	–	–	–	–	–	–
Wetlands converted to forest land	–	28.42	–	–	–	–	–	–
Other land converted to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	10.47	–	–	–	–	–	–
KP deforestation	16.33	44.95	–	–	77.3	–	39.03	–

Table 212: Random-sampling error for below-ground biomass

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest land remaining forest land	1.05	1.03	2.18	12.50	3.84	3.80	1.98	1.97
Forest land converted to cropland	55.59	–	–	–	–	–	–	–
Forest land converted to grassland	43.11	–	–	–	–	–	–	–
Forest land converted to settlements	18.49	–	–	–	–	–	–	–
Forest land converted to wetlands	64.93	–	–	–	–	–	–	–
Forest land converted to other land	–	–	–	–	–	–	–	–
Cropland converted to forest land	–	25.41	–	–	–	–	–	–
Grassland converted to forest land	–	14.80	–	–	–	–	–	–
Settlements converted to forest land	–	20.93	–	–	–	–	–	–
Wetlands converted to forest land	–	28.31	–	–	–	–	–	–
Other land converted to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	10.23	–	–	–	–	–	–
KP deforestation	16.01	2.45	–	–	77.86	–	38.50	–

7.2.5.2.5 Error budget

Finally, the error sources and error frameworks described in the previous sections are combined to form a total error budget. For the old German Länder, and for the period 1987 – 2002, a complete budget can be prepared. The relevant error values are listed in Table 213, while the total error budget is presented in Table 298 through Table 300 in Chapter 19.5.1.2.1. For the period 2002 – 2008, the data permit only an error calculation for the class *Forest Land remaining forest land* (cf. Table 214). The complete error budget is shown in Table 301 in Chapter 19.5.1.2.1. With data from the BWI 3 inventory, which is expected to be concluded in 2012, it will be possible to close the remaining gaps. In the 2002 - 2008 period, the C-stock change in the LULUCF class *Forest Land remaining forest land* shows a significant increase, amounting to 2.64 Mg ha⁻¹.

Table 213: Total error in estimation of C stocks and C-stock changes between 1987 and 2002, in the old German Länder

LULUCF category	1987		2002		1987-2002	
	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]
Forest land remaining forest land	9.64	9.68	9.09	9.14	7.14	7.20
Forest land converted to cropland	45.48	52.64	–	–	45.48	52.64
Forest land converted to grassland	36.75	39.39	–	–	36.75	39.39
Forest land converted to settlements	17.21	20.5	–	–	17.21	20.50
Forest land converted to wetlands	59.08	64.10	–	–	59.08	64.10
Forest land converted to other land	–	–	–	–	–	–
Cropland converted to forest land	–	–	22.83	26.57	22.83	26.57
Grassland converted to forest land	–	–	15.21	17.48	15.21	17.48
Settlements converted to forest land	–	–	18.54	22.83	18.54	22.83
Wetlands converted to forest land	–	–	23.26	28.18	23.26	28.18
Other land converted to forest land	–	–	–	–	–	–
KP afforestation	–	–	11.98	13.4	11.98	13.40
KP deforestation	15.67	17.60	–	–	15.67	17.60

Table 214: Total error in estimation of C stocks and C-stock changes between 2002 and 2008 in Germany

LULUCF-category	2002		2008		2002-2008	
	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]
Forest Land remaining forest land	7.58	7.62	7.33	7.36	29.68	29.69

7.2.5.3 Uncertainties in estimation pertaining to forest-floor litter and mineral soils

7.2.5.3.1 Error in taking of samples

In soil sampling, proper separation of litter and mineral soil can present a problem, since the transition between the two compartments cannot always be unambiguously identified. This problem becomes all the more important in light of the fact that carbon concentrations in litter are considerably higher than they are in mineral soil below the litter. In sampling, imprecise or improper separation between litter and mineral soil can thus have major impacts on the carbon stocks measured in a relevant horizon or depth level.

7.2.5.3.2 *Small-scale variability*

Due to the high spatial variability in litter and mineral soil, and because carbon stocks maintain spatial continuity only over short distances, sampling of carbon stocks in such compartments is subject to a high degree of uncertainty. For litter in a beech forest, SCHÖNING et al. (2006) calculated stocks of 4.0 MgC ha⁻¹, with a variation coefficient of 38 %. In mineral soil (0 - 36 cm), they found carbon stocks of 64.0 Mg ha⁻¹, with variation coefficients between 30 % and 43 %. Similar values have been recorded by LISKI (1995). He showed that different carbon stocks under a spruce site, and within a given horizon, were spatially independent as of a separation of 8 m.

7.2.5.3.3 *Representativeness of points within strata*

One problem in analysing samples in accordance with main soil units resulted from the different degrees to which classes were represented. Small classes lack statistical validity with respect to a major basic totality. Where no comparison between BZE I and BZE II / BioSoil data was possible, as a result of a lack of pertinent data, it was not possible to include the relevant forested main-soil-unit area in the calculation. In addition, it was not possible to have all main soil units represented, since some are found only on small areas of Germany's territory. All in all, as a result of this difficulty, 4.3 % of the forest area was not taken into account in this context.

7.2.5.3.4 *Database*

For about half of all sampled points, complete data sets are not available. For this reason, the present results, which of course do not take account of the lacking data, cannot be seen as a final result of the evaluation.

7.2.5.3.5 *Sampling error*

In calculation of the sampling error with regard to stock changes in litter and mineral soil, paired and unpaired samples were differentiated, and stratification of mineral soils was taken into account. The variance of the mean stocks in stratum I, and of the unstratified total sample with n_l sampling points, was calculated as follows:

Equation 33

$$v\langle\bar{Y}_l\rangle = \frac{1}{n_l(n_l - 1)} \sum_{j=1}^{n_l} (Y_{lj} - \bar{Y}_l)$$

For paired samples, the variance of the mean stock changes in stratum I, between times t_1 and t_2 , was calculated via:

Equation 34

$$v\langle\bar{G}_l\rangle = v\langle\bar{Y}_{lt_2}\rangle + v\langle\bar{Y}_{lt_1}\rangle - 2r_{y^2y^1} \sqrt{v\langle\bar{Y}_{lt_2}\rangle} \sqrt{v\langle\bar{Y}_{lt_1}\rangle}$$

where

$$r_{y^2y^1} = \frac{s_{y^2y^1}}{s_{y^2y^1}}$$

and

$$s_{y^2y^1} = \frac{1}{n_l(n_l - 1)} \sum_{j=1}^{n_l} (Y_{lj_{t_2}} - \bar{Y}_{l_{t_2}})(Y_{lj_{t_1}} - \bar{Y}_{l_{t_1}})$$

For unpaired samples, the variance of stock changes was calculated via:

Equation 35

$$v\langle \bar{G}_l \rangle = v\langle \bar{Y}_{l_{t_2}} \rangle + v\langle \bar{Y}_{l_{t_1}} \rangle$$

The total variance, throughout all strata, was estimated, taking account of the area shares w_l / w for strata, as follows:

Equation 36

$$v\langle \bar{Y} \rangle \approx \sum_{l=1}^L \left(\frac{w_l}{w} \right)^2 v[\bar{Y}_l]$$

and with

Equation 37

$$v\langle \bar{G} \rangle \approx \sum_{l=1}^L \left(\frac{w_l}{w} \right)^2 v[\bar{G}_l]$$

The carbon-stock changes for litter were calculated on the basis of paired samples, with no stratification. A sampling error of 0.03 Mg ha⁻¹, or 75%, was obtained. In calculation of carbon-stock changes in mineral soil, the overall sample was divided into a paired sample set and an unpaired sample set. In addition, stratification, in keeping with the applicable main soil units and the two sample sub-sets, was carried out. The error reached values of 0.16 Mg ha⁻¹ for the unpaired samples, and of 0.06 Mg ha⁻¹ for the paired samples. Overall, the sampling error for mineral soils amounted to 0.07 Mg ha⁻¹, or 13 %.

7.2.5.4 Time-series consistency

A time series is consistent if it is consistent within itself, is meaningful and has no internal contradictions. All of the time series concerned are consistent. While some time series contain "jumps", for methodological reasons, such jumps result from the available data, i.e. they do not constitute contradictions with regard to time-series consistency.

7.2.6 Source-specific quality assurance / control and verification (5.A)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. As a result of limitations of resources, it was not possible for the Single National Entity to carry out the additional quality assurance.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for ATKIS® and BÜK 1000 input data, and for wildfire statistics, is the responsibility of the relevant data administrators.

7.2.6.1 Biomass and dead wood

The estimates of carbon stocks in the biomass and dead wood pools, at the various relevant times, and the estimates of carbon-stock changes are based on extrapolations that were carried out at the Institute of Forest Ecology and Forest Inventory of the Johann Heinrich von Thünen Institute (vTI-WOI) and that use data from the National Forest Inventories and from the Inventurstudie 2008. With regard to the quality assurance developed for the Federal Forest Inventory, we call attention to the literature for the Federal Forest Inventory (BMELV 2005). In work carried out independently of the vTI-WOI's calculations, the estimated C stocks and C-stocks changes in relevant biomass were calculated at the Institute for World Forestry of the Johann Heinrich von Thünen Institute (vTI-WFW) with a programme developed under PostGreSQL. The results of the two sets of calculations agree.

For the first time, extensive error analysis was carried out for the biomass pool, and an attempt was made to quantify all existing sources of error. At the conclusion of the error-analysis process, a summarising global error budget was prepared.

7.2.6.2 Litter and mineral soils

In order to achieve a consistent standard of laboratory analysis in analysis of sampling carried out in the framework of the BZE and BioSoil surveys, ring analysis was initiated. To that end, all laboratories underwent a quality test carried out by the Gutachterausschuss Forstliche Analytik ("forestry analysis auditors' committee" (BLUM & HEINBACH 2006, 2007). To ensure the comparability of the applicable laboratory methods, only laboratories that participated successfully in the ring analysis were permitted to carry out relevant analysis. Ring analysis was also carried out at the European level, with German participation (COOLS et al. 2006).

To harmonise laboratory measurements and topographical surveys, rules for determining relevant parameters were defined, in the framework of the BZE II survey, for participating laboratories. This was done with a view to preventing any discrepancies resulting from use of different analysis equipment or methods (KÖNIG et al 2005, WELLBROCK et al. 2006). Previous ring analyses served as the basis for certifying laboratories for relevant analysis. A similar approach was taken with regard to field sampling. On the basis of various preliminary studies, suitable sampling methods were defined and specified, and described in a field-sampling manual (WELLBROCK et al. 2006).

7.2.6.3 Comparison with results of other countries

A comparison of carbon-stock changes in living biomass (cf. Table 215) shows that Germany, along with Austria and the Netherlands, has the highest values in the land-use-change categories and, thus, the largest carbon stocks. In the category "forest land remaining forest land", on the other hand, Germany is in the lower range, the range with the lowest storage levels. Carbon-stock losses were found in Denmark, and no changes in carbon stocks were seen in Switzerland. The largest levels of carbon storage, and the largest levels of land-use changes, were seen in the Netherlands, Austria and Poland. The comparison of Germany and its neighbouring countries shows that the results are plausible in light of the relevant forests' age-class distributions.

In the area of dead organic substance (cf. Table 216), Germany shows the largest carbon storage levels in conversions to forest land, with the exception of conversions from

grassland. Carbon storage in France is on a similar level. In the area of forest land remaining forest land, Germany occupies a mid-range position. The highest level of carbon storage in this area is seen in the Netherlands and in Switzerland. France is the only country to show carbon-stock losses in this area.

In the area of mineral soils (cf. Table 217), Germany ranks within the lower range with regard to carbon stocks formed via land-use changes. Significantly greater storage performance in this area is seen in Austria, Belgium and Poland. At present, Germany does not report any figures in the area of forest land remaining forest land.

No comparison was carried out in the area of carbon-stock losses in organic soils, due to a lack of data on such losses in neighbouring countries.

Table 215: Carbon-stock changes in living biomass, in various countries (Germany, for 2009; other countries, for 2008)

Country	Forest Land remaining Forest Land [MgC ha ⁻¹ a ⁻¹]	Land converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Cropland converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Grassland converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Wetlands converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Settlements converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Other Land converted to Forest Land [MgC ha ⁻¹ a ⁻¹]
AUT	1.18	0.98	1.18	1.18	1.18	-0.24	1.18
BEL	0.57	3.19	3.25	3.24	3.58	2.68	2.83
CHE	0.00	0.24	2.45	0.22	-0.05	1.18	0.19
CZE	0.65	1.83	1.83	1.83	1.83	1.83	NA
DNK	-0.25	-0.12	-0.28	2.88	0.04	NA.NO	-0.11
FRA	0.93	1.37	1.56	1.38	1.23	1.30	1.34
GBR	NO	1.48	1.34	1.48	IE	1.71	NO
GER	0.44	3.13	3.56	3.00	3.27	3.35	0.00⁶⁶
NLD	1.53	3.09	3.09	3.09	3.09	3.09	3.09
POL	1.15	0.55	0.55	0.55	NO	NO	NO

Source: UNFCCC 2010

Table 216: Carbon-stock changes in dead organic mass, in various countries (Germany, for 2009; other countries, for 2008)

Country	Forest Land remaining Forest Land [MgC ha ⁻¹ a ⁻¹]	Land converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Cropland converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Grassland converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Wetlands converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Settlements converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Other Land converted to Forest Land [MgC ha ⁻¹ a ⁻¹]
AUT	0.04	IE	IE	IE	IE	IE	IE
BEL	0.06	NO	NO	NO	NO	NO	NO
CHE	0.18	0.13	NO	0.13	0.17	0.08	0.18
CZE	NO	NA.NO	NO	NO	NO	NO	NA
DNK	0.02	0.18	0.16	1.88	0.20	NA.NO	0.08
FRA	-0.07	0.42	0.44	0.42	0.45	0.43	0.41
GBR	NO	0.27	0.26	0.28	IE	0.24	NO
GER	0.09	0.50	0.50	0.50	0.50	0.50	0.0066
NLD	0.25	NE	NE	NE	NE	NE	NE
POL	NO				NO	NO	NO

Source: UNFCCC 2010

⁶⁶ no areas available

Table 217: Carbon-stock changes in mineral soils, in various countries (Germany, for 2009; other countries, for 2008)

Country	Forest Land remaining Forest Land [MgC ha ⁻¹ a ⁻¹]	Land converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Cropland converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Grassland converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Wetlands converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Settlements converted to Forest Land [MgC ha ⁻¹ a ⁻¹]	Other Land converted to Forest Land [MgC ha ⁻¹ a ⁻¹]
AUT	NO	2.10	3.02	0.97	4.55	3.91	4.56
BEL	0.80	1.29	2.53	0.76	-0.21	3.52	3.48
CHE	IE.NO	NO	NO	NO	NO	NO	NO
CZE	NO	0.16	0.51	0.03	NO	NO	NA
DNK	NA	NA	NA	NA	NA	NA	NA
FRA	0.01	0.03	0.81	-0.08		0.04	
GBR	NO	0.46	0.46	0.46	IE	0.45	NO
GER	NR67	0.07	0.53	0.00	-0.03	0.00	0.0066
NLD	NE	NE	NE	NE	NE	NE	NE
POL	0.36	1.97	2.31	0.73	NO	NO	NO

Source: UNFCCC 2010

7.2.7 Source-specific recalculations (5.A)

As a result of recommendations made in the in-country review 2010, recalculation of the land-area matrix for the entire LULUCF sector was required. The new area matrices for the forest sector are presented in Chapter 7.2.3.1, for the old German Länder, and in Chapter 7.2.3.2, for the new German Länder. The changes in the areas lead to changes in the relevant correlated emissions.

7.2.7.1 Forest land remaining forest land

Recalculation of carbon-stock changes in biomass was required for two reasons. Firstly, in the Submission 2010, in calculation of the carbon-stock changes for the period 2002 to 2006, the new-forest land for the period 1990 to 2002 was erroneously counted as part of the forest land remaining forest land. New-forest areas have to remain for 20 years in the "new forest land" category before moving into the land-use category "forest land remaining forest land". Secondly, areas that, pursuant to the National Forest Inventory, count as forest land but are included in the forest category "non-wood soil", and thus are not forested, did not enter into the calculations of carbon stocks and carbon-stock changes. The relevant differences between the Submission 2010 and the Submission 2011, for the period 1990 through 2001, amount to about 8.2 %. For the period 2002 through 2009, they amount to about 0.9 % (cf. Table 218).

⁶⁷ Not reported (nicht berichtet)

Table 218: New recalculation of C storage in biomass, for the category "forest land remaining forest land"

Year	Biomass Submission 2010 [GgC]	Biomass Submission 2011 [GgC]	Difference [GgC]
1990	17,053	18,488	1,435
1991	17,048	18,477	1,429
1992	17,042	18,465	1,423
1993	17,037	18,454	1,417
1994	17,031	18,443	1,412
1995	17,026	18,432	1,406
1996	17,021	18,421	1,400
1997	17,015	18,409	1,394
1998	17,010	18,398	1,388
1999	17,004	18,387	1,383
2000	16,999	18,376	1,377
2001	16,994	18,365	1,371
2002	4,754	4,796	42
2003	4,752	4,792	40
2004	4,750	4,789	39
2005	4,748	4,786	38
2006	4,746	4,783	37
2007	4,743	4,780	37
2008	4,734	4,777	43
2009		4,774	

7.2.7.2 New forest land

For organic soils, use of an erroneous emission factor, $0.034 \text{ MgC ha}^{-1} \text{ a}^{-1}$, made a recalculation necessary. The correct emission factor is $0.68 \text{ MgC ha}^{-1} \text{ a}^{-1}$ (cf. also Chapter 7.2.4.5.2). In Table 219, the current values are compared with the previous year's values.

Table 219: Recalculation of C-stock losses in biomass organic soils, for the category "new forest land"

Year	Organic soils Submission 2010 [GgC]	Organic soils Submission 2011 [GgC]	Difference [GgC]
1990	-0.037	-0.791	-0.754
1991	-0.074	-1.583	-1.508
1992	-0.112	-2.374	-2.262
1993	-0.149	-3.166	-3.017
1994	-0.186	-3.957	-3.771
1995	-0.223	-4.748	-4.525
1996	-0.261	-5.540	-5.279
1997	-0.298	-6.331	-6.033
1998	-0.335	-7.122	-6.787
1999	-0.372	-7.914	-7.541
2000	-0.410	-8.705	-8.296
2001	-0.447	-9.497	-9.050
2002	-0.484	-10.288	-9.804
2003	-0.521	-11.079	-10.558
2004	-0.559	-11.871	-11.312
2005	-0.596	-12.662	-12.066
2006	-0.633	-13.454	-12.820
2007	-0.670	-14.245	-13.574
2008	-0.767	-15.036	-14.269
2009		-15.828	

Carbon storage in biomass, for the category "new forest land", had to be recalculated because errors had occurred in the annual area accumulation, and in the applicable emission factors, and biomass from the previous use had been recalculated. In the Submission 2011, the values were corrected (cf. Table 220).

Table 220: Recalculation of C storage in biomass, for the category "new forest land"

Year	Biomass Submission 2010 [GgC]	Biomass Submission 2011 [GgC]	Difference [GgC]
1990	7.16	-264.02	-271.18
1991	37.85	-189.97	-227.82
1992	68.55	-155.92	-184.47
1993	99.24	-41.87	-141.11
1994	129.93	32.18	-97.75
1995	160.63	106.23	-54.04
1996	191.32	180.28	-11.04
1997	222.02	254.32	32.3
1998	252.71	328.37	75.66
1999	283.40	402.42	119.02
2000	314.10	476.47	162.37
2001	344.79	550.52	205.73
2002	375.48	624.57	249.09
2003	406.18	698.62	292.44
2004	436.87	772.66	335.79
2005	467.56	846.71	379.15
2006	498.26	927.50	429.24
2007	528.95	1,035.72	506.77
2008	575.63	1,045.39	469.76
2009		1,118.37	

In the "litter" pool, in the "new forest" category, recalculation was carried out via re-evaluation of the time period required for mean carbon stocks in litter to form (cf. Table 221). In the

Submission 2010, a period of 100 years was assumed. The period has since been corrected, via studies (cf. Chapter 7.2.4.3.2) to 40 years.

Table 221: Recalculation of C storage in litter, for the category "new forest land"

Year	Forest-floor litter Submission 2010 [GgC]	Forest-floor litter Submission 2011 [GgC]	Difference [GgC]
1990	5.22	8.93	3.71
1991	10.44	17.85	7.41
1992	15.66	26.78	11.12
1993	20.87	35.70	14.83
1994	26.09	44.63	18.54
1995	31.31	53.55	22.24
1996	36.53	62.48	25.95
1997	41.75	71.40	29.65
1998	46.97	80.33	33.36
1999	52.19	89.25	37.06
2000	57.40	98.18	40.78
2001	62.62	107.10	44.48
2002	67.84	116.03	48.19
2003	73.06	124.95	51.89
2004	78.28	133.88	55.60
2005	83.50	142.80	59.30
2006	88.72	151.73	63.01
2007	93.93	160.66	66.73
2008	110.80	169.58	58.78
2009		178.51	

7.2.8 Source-specific planned improvements (5.A)

7.2.8.1 Land-use changes

In the new German Länder, the relevant areas and land-use changes were determined with the help of the data from the GSE FM-INT project. Forest-land parcels with an area of at least 0.5 hectares were categorised. That categorisation produced some discrepancies with forest areas as determined in accordance with the definition of "forest" used in the National Forest Inventory (BWI). A project is to be carried out with the aim determining whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005 (cf. also 19.5.1.1.3).

The National Forest Inventory 3 (Bundeswaldinventur 3; BWI 3), which is currently being prepared, will make it possible to determine relevant areas and land-use changes in a consistent manner for the entire territory of Germany. The results of BWI 3, which is being carried out from 2011 to 2012, will make it possible to estimate the areas and land-use changes for all LULUCF land categories for the period 2002 through 2012.

7.2.8.2 Litter and mineral soils

Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about half of the BZE II soil-survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving main soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition).

Furthermore, the BÜK map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).

Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time for that inventory will be determined after evaluation of the BZE II survey has been completed.

7.3 Cropland (5.B)

7.3.1 Source category description (5.B)

CRF 5.B					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
Cropland	l / t / T2	CO ₂	2.36%	2.91%	23.3%

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS/M					D				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS/M ⁶⁸					CS/T1				

The source categories *Cropland remaining Cropland* (5.B.1) und *Land converted to Cropland* (5.B.2) are key sources for CO₂ emissions, pursuant to GPG-LULUCF (IPCC, 2003), in terms of both level and trend.

Reporting in the category "cropland" covers the areas of emissions / storage of CO₂ from / in mineral and organic soils, above-ground and below-ground biomass and liming. It also covers nitrous oxide emissions from soils whose existing storage has been disturbed as a result of changes to cropland, from other land-use categories. Field burning of crop residues is prohibited by law in Germany and is thus reported with the notation key "NO".

The total CO₂ emissions from cropland cultivation amounted to 27,461.53 Gg in 2009. Of that figure, a total of 23,482 Gg CO₂ were released from agriculturally used bogs. 2,530.79 Gg CO₂ were released from mineral soils, as a result of conversion to cropland or of conversion from perennial to annual crops (or vice-versa). A total of 591.85 Gg CO₂ were stored in biomass.

An additional 1,682.96 Gg CO₂ was released as a result of liming. While this total refers non-specifically to all agricultural lands, it was assigned wholly to cropland cultivation (cf. Chapter 19.5.2.4).

⁶⁸ The entry "CS/M" refers to determination of changes in biomass stocks and in soil. Under Tier 1, changes in dead wood and forest-floor litter were estimated to be 0.

N₂O releases as a result of conversion of grassland, settlement land, wetlands, other lands and forest land to cropland have been calculated as amounting to 1.15 Gg N₂O, or 357.63 Gg CO₂ equivalents.

The trend in emissions from cropland, which showed slightly increasing emissions in the period 1990 – 2006, now shows a slightly decreasing trend, resulting from decreases in cultivated areas (cf. Figure 47).

7.3.2 *Information about the approaches used to determine areas and about the land-use databases used (5.B)*

The following data sources were used for determination of cropland areas, for determination of any land-use changes, for allocation of natural and administrative parameters, for development of emission factors for soils and biomass and for calculation of carbon stocks in soils and biomass at various times: digital maps, data from official German statistics, results of forest inventories and data from the literature (cf. Chapter 19.5.2.1). The definitions of land use, classification systems and the manner in which such definitions and systems are reflected in the LULUCF categories (5.B) are described in detail in Chapter 19.5.2.1.2.

7.3.3 *Land-use definitions and land-use classification systems, and the manner in which such definitions and systems are reflected in the LULUCF categories (5.B)*

The relevant LULUC land-use categories for the period 2000 – 2005, and for the years 2006, 2007, 2008 and 2009, were identified via a "wall-to-wall" approach. For identification and spatial allocation of land-use categories, data records were correlated, throughout the entire area under consideration and in a GIS-technology framework. Via comparison with data records of various relevant years, land-use changes throughout Germany were identified. All such data was georeferenced. The gross changes were determined. In the so-generated area matrix, the resulting forest-relevant values (forest, land-use changes to/from forest) were replaced with the BWI data, which then served as a fixed reference. This approach provided consistency with source category 5.A and with KP-LULUCF. Table 222 shows the land-use changes matrix for 2008/2009. The procedures for determining outset parameters, as well as land areas and usage changes, are described in detail in the Annex, Chapter 19.5.2.1/19.5.2.2.

In the period 2000-2009, the discrepancies between the BWI forest areas and the ATKIS® forest areas averaged 1.1 ± 0.8 %. The largest discrepancies occurred in the years 2006 and 2007 (2.4 %), while the smallest were seen in 2000 (0.02 %). The differences between the BWI and ATKIS® forest-area data are thus of a magnitude that approximately corresponds to the uncertainty in the ATKIS® area data.

Table 222: Land-use changes matrix for 2008/2009, for Germany

[kha]	Area change (BWI/ATKIS)					
Initial\final	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land
Forest land		0.39	1.79	0.74	4.06	0.00
Cropland	2.20	3.31	45.75	0.41	12.29	0.00
Grassland	12.10	30.18	9.35	2.30	12.53	0.00
Wetlands	1.21	0.13	0.54	0.32	1.13	0.00
Settlements	2.34	4.67	12.53	1.50	0.52	0.00
Other land	0.00	0.14	3.92	0.77	1.32	0.00
Σ additions	17.85	35.51	64.54	5.72	31.32	0.00
Σ reductions	6.98	60.65	57.11	3.01	21.04	6.16
Balance	10.87	-25.14	7.43	2.71	10.28	-6.16

Calculation of land uses and land-use changes for the period 1990–2000 was based on annual land-use changes in the period 2000–2005. On the basis of the ATKIS® land-use map for 2000, the so-determined land-use changes areas were used for extrapolation of land-use changes into the past. That, in turn, made it possible to reconstruct the land-use-change distribution for the years 1990 through 2000.

Pursuant to IPCC GPG LULUCF (2003), carbon-stock changes in soil and biomass stocks are reported under the category "cropland". In the area of soils, a distinction was made between organic and mineral soils. In the biomass category, whole-plant values, including crop residues and other litter, were entered into the balance. As a result, the pool "dead organic substance" is reported as "IE". In Germany, quantities of cuttings from multiannual plants, such as plants grown in vineyards and fruit plantations, are normally about equivalent to net-growth quantities. Since that equivalence represents a balance, the relevant dead organic substance is not reported. The data sources and definitions on which reporting for the "cropland" category is based are described in detail in Chapter 19.5.2.1.2. Allocation of ATKIS object types to IPCC's "cropland" land-use category is described in Table 306, while the possible land-use changes and resulting pertinent sub-categories are described in Table 307, in that same chapter.

7.3.4 Methodological issues (5.B)

7.3.4.1 Mineral soils

For each sub-area, the carbon-stock changes in mineral soils were calculated as the difference between the final carbon stock (after the use change) and the initial carbon stock (before the use change). The final carbon stock was determined by multiplying the area affected by a use change with the carbon stock – corrected via an emission factor – for the relevant land-use class.

The equation is as follows:

$$C_{\Delta} = C_f - C_i = A * EF * C - A * C$$

where:

- C_{Δ} : Change in carbon stocks as a result of the use change
in t / circle * monitoring period
- C_f : Final soil carbon stock in t
- C_i : Initial soil carbon stock in t
- A : Area on which land-use change has occurred, in ha
- EF : Dimensionless emission factor
- C : Polygon-specific carbon stock, in t/ha

The carbon-stock changes in the soils and in biomass were estimated with the help of specially developed programmes that calculate the stocks, in accordance with soil types and biomass stocks, for the various sub-areas and years, assign the stocks to the relevant CRF categories, sum the stocks on a nation-wide basis and then output them in conformance with the CRF tables (cf. Chapter 19.5.2.3, in the Annex).

The N₂O emissions as a result of conversion of land to cropland (CRF Table 5 (III)) were determined pursuant to GPG (2003). To this end, the carbon-stock changes determined for the various individual polygons were divided by the C/N ratios for the pertinent soils, to obtain the changes in nitrogen stocks. The resulting changes were then combined with the default value of 0.0125 t N₂O-N/t N; this yielded the relevant N₂O emissions. The C/N ratios were derived from the lead-profile data provided by the Federal Institute for Geosciences and Raw Materials (BGR) along with the BÜK 1000 (BGR 1997).

7.3.4.2 Organic soils

The carbon-stock differences for organic soils were estimated on the basis of values from the literature. In a CarboEurope study, BYRNE et al. (2004) report figures of 0.82 – 6.58 t C ha⁻¹a⁻¹ for carbon emissions from organic grassland soils, and figures of 1.09 – 10.6 t C ha⁻¹a⁻¹ for emissions from cropland soils. At an average of 4.09 t C ha⁻¹a⁻¹, these values are too low, especially with regard to cropland, since the study was based primarily on data for boreal soils. MUNDEL (1976), GENSIOR und ZEITZ (1999), MEYER (1999) and AUGUSTIN (2001) report losses in grassland areas ranging from 2.46 – 7.63 t C ha⁻¹a⁻¹, and HÖPER (2002) reports a range of 4.6 – 16.5 t C ha⁻¹a⁻¹, with bogs used as cropland reaching 10.6 – 16.5 t C ha⁻¹a⁻¹. The report uses an emission factor of 5 t C ha⁻¹a⁻¹ for grassland and a figure of 11 t C ha⁻¹a⁻¹ for cropland; these figures are based primarily on data collected in Germany. The organic-soil areas in question, and the relevant uses, were determined via a georeferencing procedure involving intersection of BÜK 1000 and ATKIS® data. More detailed remarks regarding the relevant methods and definitions are presented in Chapter 19.5.2.1.3.

7.3.4.3 Biomass

The carbon-stock changes in biomass are estimated by subtracting the biomass carbon stock before the use change from the stock after the use change, with reference to the area affected by the change:

$$\Delta C_{\text{Bio}} = C_{\text{Bio}f} - C_{\text{Bio}i} = A * EF_{\text{final}} - A * EF_{\text{initial}}$$

where:

ΔC_{Bio} :	Change in carbon stocks in biomass in t* ¹ polygon ⁻¹ *monitoring period ⁻¹
$C_{\text{Bio}f}$:	Final biomass carbon stock in t
$C_{\text{Bio}i}$:	Initial biomass carbon stock in t
A:	Area on which land-use change has occurred, in ha
EF_{final} :	Plant-specific biomass carbon stock in t/ha (after use change)
EF_{initial} :	Plant-specific biomass carbon stock in t/ha (before use change)

Biomass carbon stocks were mathematically combined pursuant to GPG-LULUCF (IPCC, 2003) (cf. also Chapter 19.5.2.3.2 in the Annex). The present report uses biomass emission factors for each of the years since 2000. Specially developed programmes (cf. Chapter 19.5.2, in the Annex) were used for combination, category-oriented summation and output of the data in keeping with the CRF categories.

7.3.5 *Uncertainties and time-series consistency (5.B)*

The spatial uncertainties for determination of land-use changes via ATKIS® are very small, since the procedure chosen is a "wall-to-wall" method. Any errors that occur in the process are based in the original data. The data precision is given as ± 3 m (BKG). The many different transformation and calculation steps involved in using ATKIS® data produce an average error, in offsetting and rounding-off, of 0.31 % (and a median of 0.13). This error varies over the years, and within the various land-use categories, between 0.02 % and 3 %; the median is 0.03. As a result of the "wall-to-wall" approach used, of georeferencing of individual polygons and of use of unique identification numbers, there is no possibility for any areas to be counted double.

Another error results from data records for the ATKIS® 1:250,000-scale administrative boundaries, which are used for norming all systems. Those data are considerably less precise than the Basis-DLM data. They lead to errors in peripheral areas of the national territory, errors amounting to a total of < 1 %.

Since the agency that administrates ATKIS® does not archive older versions, an annually based time series is available for the ATKIS® system only as of 2005. On the other hand, reporters have access to a consistent ATKIS® version for the year 2000, and that version is a suitable basis for reporting for the period as of 2000.

Because the ATKIS system underwent three different implementation stages (through 2008), technical corrections of boundaries had to be carried out repeatedly (cf. Chapter 19.5.2.1.1.4). In the LULUC reporting system, such technical area changes are identified as land-use changes and cannot be distinguished from actual land-use changes (cf. Chapter 19.5.2.1.1.4). On the basis of the relevant comparison data from the National Forest Inventory (Bundeswaldinventur), the resulting uncertainty is estimated at about 3 %.

At the recommendation of the In-country Review Team 2010, more precise analyses were carried out of CORINE and ATKIS® (BASIS-DLM) data that serve as a basis for showing non-forest land uses for the period 1990 through 2000. Those analyses revealed that it is not possible to produce a consistent land-use matrix and time series, for the period until 2000, by combining CORINE and ATKIS®. The CORINE land-use map is not consistent with the ATKIS® land-use map (cf. NIELAND 2009 – for example, p.87). For this reason, the CORINE map was not used (cf. Chapter 7.3.6). Production of a consistent time series is described in Chapter 19.5.2.1.1.5.

In estimation of soil carbon losses, the stock changes per area unit range between 45 % - 53 % of the reported mean value. The errors in determination of emissions from organic soils are very large, possibly ranging up to 75 % - > 100 %. The reasons for such error are found in the relevant emission factors, which are derived from the literature (errors of 75 % - > 100 %), and in the still-imprecise classification of organic soils.

As a result of the procedure used for estimating N₂O, the errors occurring in determination of carbon stocks propagate themselves. In addition, the uncertainty increases as a result of use of the default procedure. The uncertainty is estimated to be 100 %.

The errors arising in biomass determination – errors arising via the estimation procedure used for the present report (determination of an average carbon emission factor for each district; use of Länder harvest data for grassland and of default values for woody plants) – cannot be determined until area-based data for the relevant biomass are available and

country-specific emission factors for woody plants have been obtained. The uncertainty is given as 75 %, on the basis of an expert assessment.

7.3.6 Source-specific quality assurance / control and verification (5.B)

Quality control (in accordance with Tiers 1 + 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. It was not possible to carry out quality assurance.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Internally, the possibility of determining uncertainties via data manipulation with cross-sum comparisons is being reviewed. Quality assurance for input data (ATKIS[®], BÜK, official statistics) is the responsibility of the relevant data administrators. No special third-party QA/QC checking is carried out.

7.3.7 Source-specific recalculations (5.B)

For this year's report, the data for the entire report period, 1990 – 2009, have been completely recalculated (and are so presented) to take account of the transition in the reporting system. In addition, land use in the period 1990 – 2000 has been re-reconstructed and recalculated, via backward extrapolation from the ATKIS[®] data, in order to eliminate inconsistencies, in the time series and area categorisations, that occurred via use of the CORINE Land Cover data for that period.

Furthermore, the emissions from liming have been recalculated. The emissions have been corrected to take account of the CO₂ quantities that would have resulted from the lime quantities that had been calculated, erroneously, from the CaO figures for burnt lime and slag lime. As a result of the data correction, the tables for the entire report period, 1990 – 2009, are now spatially and chronologically consistent and complete.

7.3.8 Source-specific planned improvements (5.B)

Complete conversion of the LULUC reporting system is planned for the next two years (cf. the answer to the ERT: Action plan for resolving issues identified by the ERT regarding KP LULUCF, Chapter 19.5.2.7). At the recommendation of the ERT, more precise analyses were carried out of CORINE and ATKIS[®] (BASIS-DLM) data to provide a basis for showing non-forest land uses for the period 1990 through 2000. Those analyses have shown that the CORINE land-use map is not consistent with the ATKIS land-use map. The existing GIS system thus cannot be used to produce a consistent land-use matrix and time series for the period through 2000. It will thus be necessary to carry out a new, consistent reconstruction of land use for years prior to 2000 (cf. NIELAND 2009 – for example, p.87). The area-identification process, for all categories, will be converted to an approach that uses a point grid and that is consistent for purposes of reporting forest categories and reporting in the KP-LULUCF framework. In addition, that method will simplify use of other data/sources, such as data from the European LUCAS grid, and satellite/aerial photos, etc., thereby making it possible for recalculations to 1990 to draw on additional data sources. The point raster will ensure that reporting for the "cropland" category is spatially and chronologically consistent. Additionally it will allow to display the land use changes between 1990 and 2000. That process, in turn, will also involve the following improvements:

1. Changes in the system for reporting emissions from mineral soils

- Derivation of typical, use-dependent carbon stocks in mineral soils, weighted by soil type and area, for all of Germany
 - Development of a new system for describing carbon-stock changes as a function of land use
2. National emission factors for organic soils (NIR 2013/2014)
 3. Change in the system for determining carbon-stock changes in biomass
 - Reduction in the total number of emission factors, via calculation of area-weighted mean values for all of Germany
 - An increase, over the number used to date, in the number of plant species that enter into area-weighted mean values
 - Separate calculation of carbon stocks for above-ground and below-ground biomass
 - New country-specific default factors for carbon stocks in wood plantations outside of forests (NIR 2012/2013)
 4. GPG-conformal error calculation

A more detailed pertinent discussion is presented in Chapter 19.5.2.6 in the Annex.

7.4 Grassland (5.C)

7.4.1 Source category description (5.C)

CRF 5.C					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
Grassland	l / t / T2	CO ₂	0.37%	1.13%	203.5%

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	CS/D									
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS/M ⁶⁹									

The definition of grassland includes all meadow and pasture areas that cannot be considered cropland. In addition, this category also includes land that is covered with trees and shrubs but that does not fall within the definition of "forest", as well as natural grassland and recreational areas.

The source categories *Grassland remaining Grassland* (5.C.1) und *Land converted to Grassland* (5.C.2) are key sources of CO₂ emissions, pursuant to GPG-LULUCF (IPCC, 2003), in terms of level and trend.

The anthropogenic CO₂ emissions from grassland were placed at 10,720.85 Gg for the year 2009. A total of 13,204.91 Gg CO₂ were emitted as a result of drainage of organic grassland soils. In the same period, 1,603.44 Gg CO₂ were stored in mineral soils, and 880.62 Gg CO₂ were stored in biomass, as a result of land-use changes.

⁶⁹ The entry "CS/M" refers to determination of changes in biomass stocks and in soil. Under Tier 1, changes in dead wood and forest-floor litter were estimated to be 0.

With regard to the relevant uncertainties and to liming, cf. Chapter 7.3 (CRF 5.B) and Chapter 19.5.2.4 in the Annex.

7.4.2 Information about the approaches used to determine areas and about the land-use databases used (5.C)

Cf. Chapter 7.3.2

7.4.3 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.C)

Cf. Chapter 7.3.3

7.4.4 Methodological issues (5.C)

Cf. Chapter 7.3.4

7.4.5 Uncertainties and time-series consistency (5.C)

Cf. Chapter 7.3.5

7.4.6 Source-specific quality assurance / control and verification (5.C)

Cf. Chapter 7.3.6

7.4.7 Source-specific recalculations (5.C)

Cf. Chapter 7.3.7

7.4.8 Source-specific planned improvements (5.C)

Other than the improvements set forth in Chapter 7.3.8, no improvements are to be carried out for the grassland sector in the coming years.

7.5 Wetlands (5.D)

CRF 5 D										
Key source by Level (l) / Trend (t) / Tier 2 (T2)	Gas (key source)			1990 - contribution to total emissions			2009 - contribution to total emissions			Trend
Wetlands (CRF 5.D)	- / - / T2	CO ₂								
Gas	CO₂	CH₄	HFC	PFC	SF₆	N₂O	NO_x	CO	NMVOC	SO₂
Emission factor (EF)	CS/D									
EF uncertainties in %										
Uncertainties distribution										
Method of EF determination	CS/T1	T1				T1				

The source category "Wetlands" is a key source, pursuant to Tier 2 analysis, of CO₂ emissions.

7.5.1 Source category description (5.D)

The German definition of wetlands includes semi-natural wetlands and bogs, open water areas and peat-extraction areas.

In 2009, a total of 2,408.29 Gg CO₂ were released from wetlands. That sum comprises 2,357.13 Gg CO₂ of emissions from peat extraction and use; 97.99 Gg of CO₂ emissions from biomass; and CO₂ additions of 46.83 Gg to mineral soils, via land-use changes.

The source categories *Wetlands remaining Wetlands* (5.D.1) und *Land converted to Wetlands* (5.D.2) are key sources of CO₂ emissions pursuant to GPG-LULUCF (IPCC, 2003).

Reporting in the wetlands category primarily covers emissions from organic soils that are released during peat extraction. Reporting has to cover CO₂ losses from extraction areas, and during extraction, as well as emissions resulting from spreading of peat.

In addition, reporting covers changes in carbon stocks of above-ground and below-ground biomass, and of soils that, as a result of land-use changes, now have to be categorised as wetlands. In the wetlands category, reporting does not have to cover land uses per se, since the areas in question fall into one of the other use categories. In Germany, "wetlands" include the few non-drained semi-natural bogs that have been largely free of anthropogenic impacts. Reporting does not have to cover such areas.

Reporting also does not cover changes in the carbon cycles of "flooded lands", water-storage facilities (dams, reservoirs, etc.) and settling basins that are used for energy production, irrigation, shipping and recreation, and that are flooded or drained, or that otherwise have large water-level fluctuations. In terms of their total area, such areas are insignificant in Germany and do not have to be covered in Tier 1 reporting.

7.5.2 Information about the approaches used to determine land areas and about the land-use databases used (5.D)

Cf. Chapter 7.3.2

7.5.3 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.D)

Cf. Chapter 7.3.3

7.5.4 Methodological issues (5.D)

CO₂ emissions from peat extraction were calculated in keeping with the provisions of the IPCC Guidelines 2006. Due to a lack of country-specific emission factors, a Tier 1 procedure was used, in connection with the default factors of the IPCC (2006). The activity data on which the estimate is based were taken from official German statistics (*FEDERAL STATISTICAL OFFICE*, Fachserie 4, Reihe 3.1).

Carbon-stocks changes in soils, and in biomass as a result of land-use changes, were calculated using the procedures and methods described in Chapter 19.5.2. The carbon stocks in above-ground and below-ground biomass were estimated at 30 t/ha for the relevant lands.

CH₄ emissions from peat extraction (pursuant to IPCC GPG-LULUCF 2003, p. 1.11) are not reported.

N₂O emissions from peat extraction do not have to be reported, since they are negligible. The reason for this is that almost all of the peat extracted in Germany is extracted from raised bogs, which have C/N ratios > 25 (pursuant to IPCC GPG-LULUCF 2003, p. 1.11).

7.5.5 Uncertainties and time-series consistency (5.D)

The statements made in Chapter 7.3.5, with regard to the quality of activity data for the categories of land use and land-use changes, apply here as well. The time series for activity data provided by the Federal Statistical Office for peat extraction are consistent and available for the entire period covered by the report. The extraction area has remained relatively unchanged, at about 35,000 ha. Similarly, the extracted quantities have remained at a fairly constant level; over the past six years, they have averaged $8.26 \text{ million m}^3 \pm 2.1 \%$. The largest uncertainties in this category occur via use of emission factors with error $> 100 \%$ (IPCC 2006).

7.5.6 Source-specific quality assurance / control and verification (5.D)

Cf. Chapter 7.3.6

7.5.7 Source-specific recalculations (5.D)

Cf. Chapter 7.3.7

7.5.8 Source-specific planned improvements (5.D)

In the wetlands category, an effort is being made to derive country-specific emission factors for emissions of the greenhouse gases CO_2 , N_2O and CH_4 from peat extraction. To this end, measurements are being carried out, in the framework of the project "Organic Soils", that cover all phases of this form of land use (cf. Chapter 19.5.2.6). The results are used for determination of national default factors. As soon as they become available, the results of this project are to enter into national reporting (NIR 2013).

7.6 Settlements (5.E)

CRF 5 E											
Key source by Level (l) / Trend (t) / Tier 2 (T2)		Gas (key source)		1990 - contribution to total emissions				2009 - contribution to total emissions			
Settlements (CRF 5.E)		- / - /t2	CO_2								
Gas		CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_x	CO	NMVOC	SO_2
Emission factor (EF)		CS/D									
EF uncertainties in %											
Uncertainties distribution											
Method of EF determination		CS/T1									

The source category "Settlements" is a key source, pursuant to Tier 2 analysis, for CO_2 emissions.

7.6.1 Source category description (5.E)

Reporting for the land-use category "settlements" has to cover CO_2 emissions / storage in the pools "soil", "biomass" and "dead organic matter" on land designated for settlement and transport uses. Precise definitions and category allocations are presented in Chapter 19.5.2.1. The source category *Land converted to Settlements* (5.E.2) is a key source of CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

In 2009, CO_2 emissions from Germany's settlement and transport-infrastructure areas, as a result of land-use changes, amounted to 2,278.57 Gg. That figure represents the sum of loss

of 424,32 Gg CO₂ from biomass, 1.878,12 Gg of CO₂ emissions from organic soils and storage of 23.86 Gg in mineral soils.

7.6.2 Information about the approaches used to determine areas and about the land-use databases used (5.E)

Cf. Chapter 7.3.2

7.6.3 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.E)

Cf. Chapter 7.3.3

7.6.4 Methodological issues (5.E)

The activity data for estimation of CO₂ emissions for the category "Settlements" were taken from the B-DLM of the ATKIS® (Adv) system and from the BÜK 1000 overview map (BGR 1998).

In estimation of emissions from biomass and soils, elements that fall within the categories of open settlement areas and transport areas are of particular interest. No findings are available relative to development of organic materials in mineral soils of settlement areas. For this reason, in the underlying approach, it was assumed that conversion within the "settlements" category does not lead to any changes in soil carbon stocks, even in cases in which mineral soil is not sealed (Tier 1). With regard to organic soils in settlement areas, it is assumed that such soils are either sealed or "left in a natural state", and that thus they release no anthropogenically based emissions. For this reason, only stock changes in biomass and soils, following conversion, are reported under "settlements".

7.6.5 Uncertainties and time-series consistency (5.E)

The statements made in Chapter 7.3.5, with regard to the quality of activity data for the categories of land use and land-use changes, apply here as well. Since no data are available on the biomass of the various types of areas in question, the relevant figures had to be estimated via expert judgement. The error for the pertinent underlying default factors is estimated at 75 %. The carbon stocks in biomass were estimated on the basis of default factors (error: 75 %) or harvest statistics.

The consistency of the time series is assured with regard to the ATKIS® data.

7.6.6 Source-specific quality assurance / control and verification (5.E)

Cf. Chapter 7.3.6

7.6.7 Source-specific recalculations (5.E)

Cf. Chapter 7.3.7

7.6.8 Source-specific planned improvements (5.E)

Planned source-specific improvements for this sector include determination of country-specific emission factors for vegetation cover in cities and settlements and along transport infrastructure. A preliminary study has been commissioned to this end. In that pilot project, a

method is being developed for determining carbon stocks, and their changes, in urban trees (NIR 2013/2014) (cf. Chapter 19.5.2.6).

7.7 Other land (5.F)

7.7.1 Source category description (5.F)

Since, by definition, the areas in the category "other land" consist of areas that are neither influenced nor cultivated by people, only areas designated for the purpose of completing the area matrix are included. Emissions within the meaning of IPCC LULUCF cannot occur on such areas. Therefore, no such emissions are reported.

7.7.2 Information about the approaches used to determine areas and about the land-use databases used (5.F)

Cf. Chapter 7.3.2.

7.7.3 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.F)

The following object types defined in ATKIS® are assigned to the "Other land" category within the German LULUCF report system: "area currently not classifiable" (object number 4199), and "vegetation-free areas" (object number 4120). Areas are identified and classified in keeping with the algorithms described in Chapter 19.5.2.

Cf. also Chapter 7.3.3.

7.7.4 Methodological issues (5.F)

No emissions need to be reported. Therefore, no discussion of methodological issues is required.

7.7.5 Uncertainties and time-series consistency (5.F)

Cf. Chapter 7.3.5.

7.7.6 Source-specific quality assurance / control and verification (5.F)

No systematic quality control and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the areas of liming of forest soils and drainage of forest soils.

Quality control (in accordance with Tiers 1 + 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out for the areas of liming of cropland & grassland and N₂O emissions from conversions to cropland. It was not possible to carry out quality assurance.

7.7.7 Source-specific recalculations (5.F)

Cf. Chapter 7.3.7.

7.7.8 Source-specific planned improvements (5.F)

No source-specific improvements are required.

7.8 Other areas (5.G)

The following emissions are reported under 5.G:

- Nitrous oxide emissions tied to disruptions in connection with land-use changes to cropland, since the CRF Reporter does not include N₂O emissions in sub-category *5.B.2.4 Settlement converted to Cropland*.
- CO₂ emissions from liming of forest soils, since the CRF Reporter allows only reporting of agricultural lime fertilisation.

8 WASTE AND WASTE WATER (CRF SECTOR 6)

8.1 Overview (CRF Sector 6)

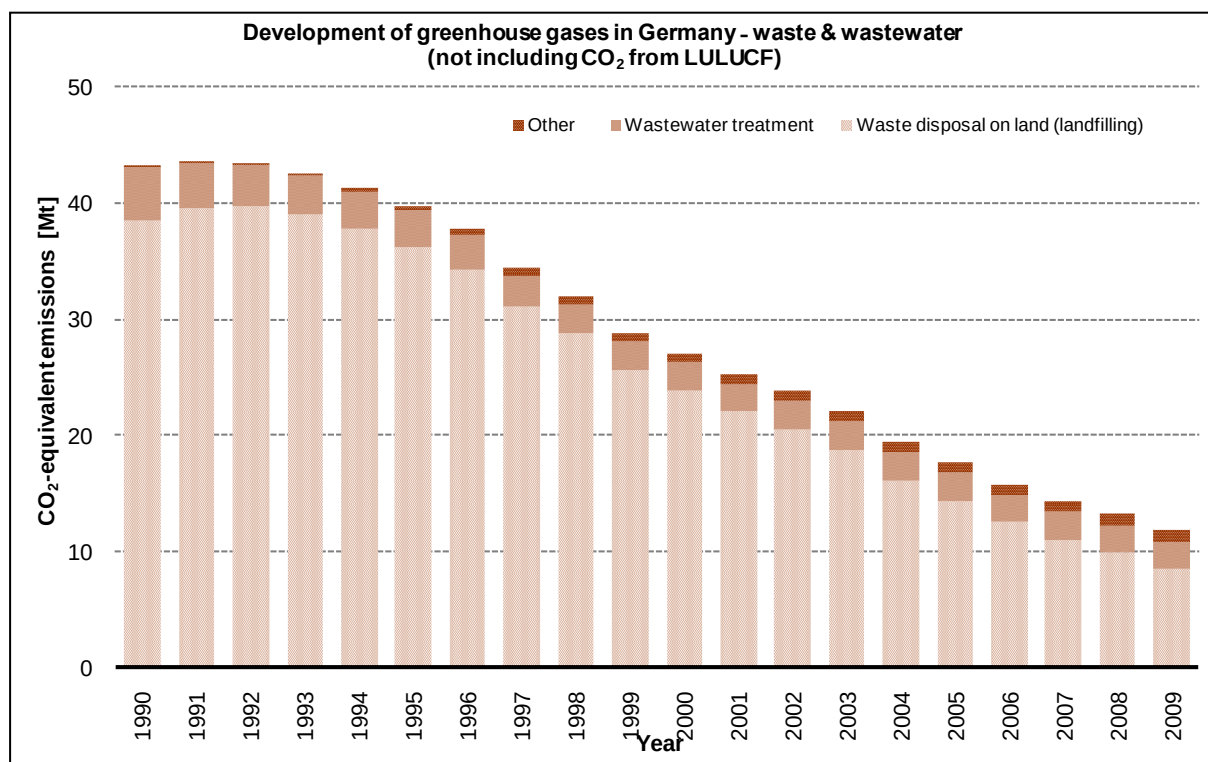


Figure 52: Overview of greenhouse-gas emissions in CRF Sector 6

8.2 Solid waste disposal on land (6.A)

CRF 6.A										
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend					
6.A.1 Solid waste disposal on land	l / t / T2	CH ₄	3.16 %	0.90 %	-78.1 %					
Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)		CS/D								
EF uncertainties in %		12.5								
Distribution of uncertainties		N								
EF-determination method		T2								

The source category *Solid waste disposal on land* is a key source of CH₄ emissions in terms of both emissions level and trend.

Only managed disposal in landfills (6.A.1) is relevant for purposes of German emissions reporting under CRF 6.A. "Wild" or illegal dumping of solid waste (CRF 6.A.2) is prohibited by law in Germany.

In light of the growing importance of other methods for treating biodegradable waste fractions, emissions from composting and from mechanical-biological waste treatment have been reported since 2004. Those emissions are reported under category 6.D Other.

In the CSE, source category 6.A Solid waste disposal on land includes landfilled household waste and sewage sludge.

8.2.1 *Managed disposal in landfills – landfilling of municipal waste* **(6.A.1)**

8.2.1.1 Source category description (6.A.1)

In the period since 1990 (and previously, to some extent), a number of legal provisions have been issued pertaining to Germany's waste-management sector, and a number of relevant organisational measures have been initiated. These moves have had a strong impact on trends in emissions from waste-landfilling. Relevant developments have included intensified collection of biodegradable waste from households and the commercial sector, intensified collection of other recyclable materials, such as glass, paper/cardboard, metals and plastics; separate collection of packaging; and recycling of packaging. In addition, incineration of municipal waste has been expanded, and mechanical-biological treatment of residual waste has been introduced. As a result of such measures, amounts of landfilled municipal waste decreased greatly from 1990 to 2006 (cf. Figure 53). As the figure shows, over half of municipal waste produced in Germany today is collected separately and gleaned for recyclable materials (separate collection of recyclable materials and biodegradable waste). Official statistical data (*FEDERAL STATISTICAL OFFICE* Fachserie 19, Reihe 1 Abfallentsorgung 2008 ("Waste management, 2008") of 13 July 2010) are available for the period until 2008. Following the drastic reduction in landfilling after 2005, linear extrapolation was carried out on the basis of the data for the years 2006 through 2008. A similar procedure was applied for source category 6.D.

In 2004, about 330 landfills for municipal waste were in operation in the Federal Republic of Germany. By that year, strict legal regulations were already in place that require such landfills to have equipment for collecting and treating landfill gas. Those regulations have extensively reduced methane emissions from such facilities. In June 2005, in keeping with new, stricter requirements under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Kitchen-Waste-Treatment Facilities (AbfAbIV) and the Landfill Ordinance (Deponieverordnung), over half of all landfills were closed. As a result, only about 150 landfills for municipal waste are now still in operation. As a result of regulations in force since June 2005, landfilling of biodegradable waste is no longer permitted. As a result, since June 2005 it has no longer been possible to landfill waste with the potential for significant methane formation. For conformance with pertinent requirements, municipal waste and other biodegradable waste must be pre-treated via thermal or mechanical-biological processes. In waste landfilled after 2006, just a few waste components (such as residues from treatment in MBT facilities; wood fractions in construction rubble) have contributed to landfill-gas formation. As landfill-gas formation in older landfills drops off, methane emissions from landfills will again decrease extensively and will then, in the long term, stabilise at a very low level.

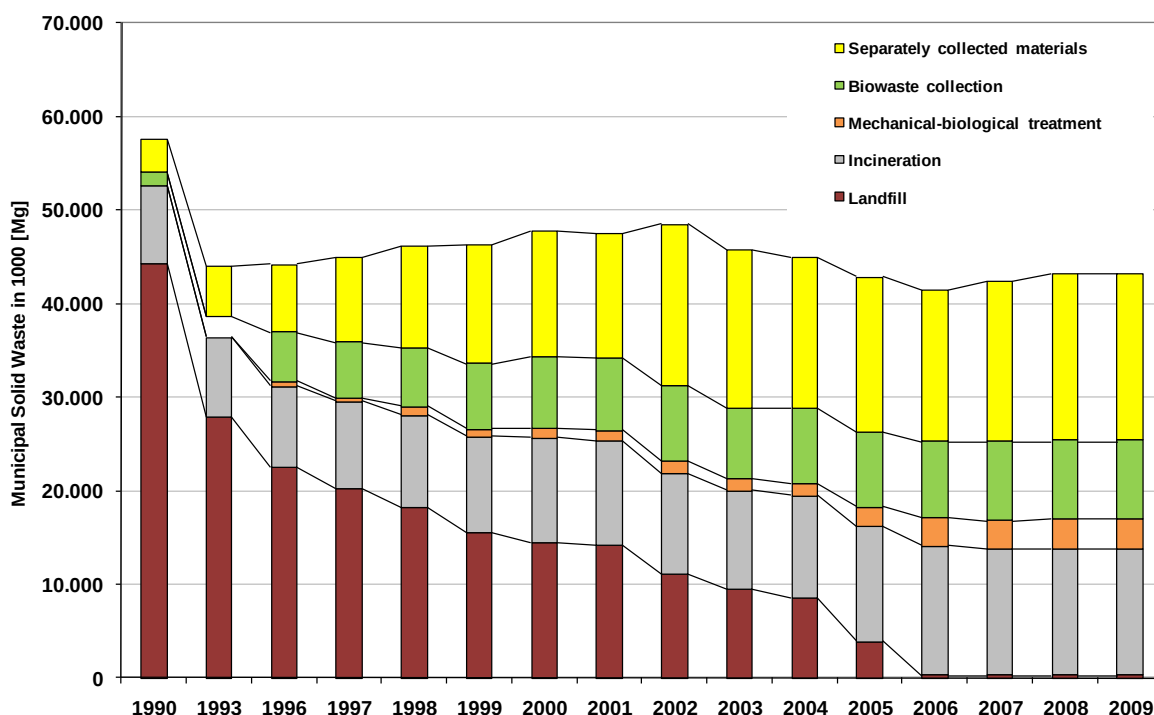


Figure 53: Changes in pathways for management of household waste, 1990 to 2009, with intermediate years

By reducing landfill methane emissions from 1.8 million Mg in 1990 to 0.4 million Mg in 2009, Germany's waste-management sector has made an important contribution to climate protection. The lower methane emissions from source category 6.A.1 amount to a decrease of 30 million tonnes of CO₂ equivalents per year and, thus, to a 3 % reduction of Germany's entire greenhouse-gas emissions. Experience gained by Germany's waste-management sector shows that reductions of landfilled quantities of biodegradable waste can provide significantly higher contributions to climate protection than can collection and treatment of landfill gas.

8.2.1.2 Methodological issues (6.A.1)

The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 1996b) specify two methods for determining methane emissions from landfills, a default method (Tier 1), known as the "mass-balance approach", and the "first order decay method" (short name: "FOD method" or "Tier 2"). Whereas the default method functions under the assumption that methane from waste forms completely in the year in which the waste is placed in a landfill, the FOD method uses a kinetic approach that describes methane formation, more realistically, as taking place over several years.

There are at least two reasons why the Tier 1 method is inadequate for determining emissions in Germany:

IPCC *Good Practice Guidance* (IPCC, 2000) specifies that the first order decay method should be used when source category 6.A is a key source. At present, this source category is a key source in Germany in terms of emissions levels and trend.

The default method tends to underestimate emissions especially when quantities of waste being placed in landfills are decreasing, and this is occurring in Germany. For these reasons, in the following section, CH₄ emissions were calculated with the FOD method (Tier 2).

The following section describes the FOD method, and the relevant parameters used, for determining methane formation in landfills. The FOD method calculates in accordance with Equation 38:⁷⁰

Equation 38 (IPCC 2000 Good Practice Guidance, Equation 5.1):

$$CH_4 \text{ produced in year } t \text{ (Gg / year)} = \sum_x [(A * k * MSW_T(x) * MSW_F(x) * L_0(x) * e^{-k(t-x)})]$$

$$\text{where: } L_0 \text{ (GgCH}_4 \text{ / kgWaste)} = MCF * DOC * DOC_F * F * 16/12$$

for x = first year to t

where:

t	= Inventory year
x	= Year as of which the consideration begins and quantities data are collected
$MSW_T(x)$	= Total quantity of municipal waste
$MSW_F(x)$	= Portion of waste that is landfilled
A	= $(1 - e^{-k})/k$ = Normalisation factor for sum correction
k	= Constant methane-formation rate (1/year)
L_0	= Methane-formation potential
$MCF(x)$	= Methane correction factor for year x
$DOC(x)$	= Decomposable organic carbon in year x (relevant share)
DOC_F	= Fraction of converted DOC in landfill gas
F	= Fraction of CH_4 in landfill gas
$16/12$	= Conversion of C to CH_4

A multi-phase model was used that calculates with, and then sums, a range of different half-lives for the various waste fractions involved, pursuant to Equation 38.

To obtain the final CH_4 -emissions result, methane that is collected and then flared, or then used for energy recovery, is deducted, and a correction factor is applied that accounts for methane oxidation in landfill covering layers, as shown by Equation 39:

Equation 39 (IPCC Guidelines, Equation 5.1):

$$CH_4 \text{ emitted in year } t \text{ (Gg/year)} = (CH_4 \text{ produced in year } t - R(t)) * (1 - OX)$$

Where

$R(t)$	= CH_4 collection in year t
OX	= Oxidation factor (fraction)

For both Tier 1 and Tier 2, the relevant quantities of municipal waste (MSW_T), and the proportion of municipal waste that is landfilled (MSW_F), must be determined; for Tier 2, production of municipal waste over the previous decades must also be determined. Pursuant to IPCC Good Practice Guidance (2000), landfilled settlement waste should be broken down – via estimation – into waste types, since the further procedure takes account of the fact that different waste types have different DOCs values.

8.2.1.2.1 Quantities of landfilled waste

The FOD model calculates emissions from landfilled municipal waste, landfilled industrial waste and landfilled sewage sludge.

Pertinent quantities of landfilled municipal waste (household and commercial waste) are taken from relevant statistics of the Federal Statistical Office, which are based on annual

⁷⁰ A detailed description of the FOD method and its parameters is presented in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, in the Greenhouse Gas Inventory Reference Manual, known as the "IPCC Guidelines" (IPCC 1996b), and in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, known as the "Good Practice Guidance" (IPCC 2000).

surveys of waste types, origins and final destinations, as well as on surveys taken of waste-storage facilities, every two years, that focus on specific equipment of the facilities. The surveys of landfilled quantities of municipal waste in the old German Länder commenced in 1975, on the basis of the Environmental Statistics Act of 1974. Waste quantities for the period from 1950 to 1975 were extrapolated on the basis of population data.

For the new German Länder, data on landfilled quantities of municipal waste, differentiated by Länder, is available for the years 1990 and 1993. For the 1980s in the former GDR, LALE (2000) has presented data that provide information about per-capita landfilled quantities of waste, waste composition, landfill types and types of waste storage involved. The per-capita quantities of landfilled waste in the former GDR, at 190 kg/person, were considerably lower than the corresponding quantities in the old German Länder (330 kg / person and year). This has to do with the fact that larger percentages of waste were recycled in the former GDR. In 1990, the year of German reunification, landfilled quantities of waste increased sharply in the new German Länder, to the extent that the relevant per-capita quantities even outstripped the corresponding quantities in the old German Länder. The reasons for this were that the former GDR's recycling systems collapsed in that year and that a flood of new products suddenly became available, leading to high levels of replacement purchases and to sharply increasing quantities of packaging waste. Since 1990, per-capita waste quantities in both parts of Germany have slowly been moving into alignment. In the former GDR, all non-recycled waste quantities were landfilled.

Since 1996, the Federal Statistical Office has published differentiated data on waste-landfilling by industry. The relevant inventory takes account of the landfilled waste quantities from industrial sectors as follows:

- Waste from agriculture, horticulture, forestry, fisheries and food processing
- Waste from wood processing
- Waste from production of pulp, paper and carton
- Waste from the textile industry
- Packaging waste
- Wood fractions in construction and demolition waste (data since 1975)

The quantities of industrial waste landfilled between 1975 and 1996 were derived on the basis of total quantities of landfilled waste. While the total quantities include industrial waste, the total-waste figures are not broken down to show industrial waste separately. Extrapolations between waste production and production data of relevant sectors, for the 1996-2002 period, produced no satisfactory statistical relationships. While production figures increased, waste-production figures decreased – considerably, in part – as a result of changes in production processes. Due to the lack of statistical relationships, the figures for landfilled waste quantities were kept constant for the period between 1950 and 1975. Changes in assumptions relative to industrial waste in the 1950-1970 period have only a very marginal effect on emissions in the base year.

Data on landfilling of sewage sludges from public and industrial wastewater treatment is available for the old German Länder for the period since 1975. Those data have been extrapolated via population data (public wastewater treatment), under the assumption that quantities of sewage sludge (industrial waste) remained constant. Here as well, changes in assumptions regarding industrial quantities for the 1950-1970 period have only slight impacts on base-year emissions, because the half-life for sewage-sludge decomposition in landfills is short – four years.

Waste composition

For purposes of inventory calculation, numerous studies on waste composition were evaluated to determine historical trends in waste fractions. In the years 1980 and 1985, waste composition was determined for the entire territory of the former Federal Republic of Germany (UBA 1983, 1986). For the subsequent period, a large number of individual studies exists – studies carried out by individual cities, administrative districts and Länder. Some of these had already been evaluated and combined within overarching studies. The pertinent figures were used to obtain time series for waste composition for the period between 1980 and 2005 (cf. Figure 55). Such evaluation of existing studies was carried out for household waste, household-like commercial waste and for bulky waste, categories that are listed separately in national statistics. As to waste composition in the new German Länder, the figures provided by LALE (2000) for the 1980s in the former GDR were adopted (composition of household waste: 28 % vegetable waste, 14 % paper/cardboard, 2.3 % wood, rubber, composites, 3 % textiles; household waste accounted for only 16 % of total landfilled waste quantities, however). Quantities of municipal waste landfilled in the former GDR contain smaller fractions of biodegradable materials and large inorganic fractions (primarily ash from household combustion systems). Food waste was collected and used as feed; feeds tended to be scarce during certain periods of time. Paper was collected; it was also a scarce resource. Wood and paper were often burned in ovens for purposes of heating and cooking. The "SERO" recycling system efficiently collected the country's relatively small fractions of plastic packaging. Deposit systems were operated for glass, and glass was also collected. All in all, the former GDR's economy was subject to scarcities of resources, and this led to efficient waste recycling. Ash from household combustion systems accounted for large fractions of landfilled quantities of household waste.

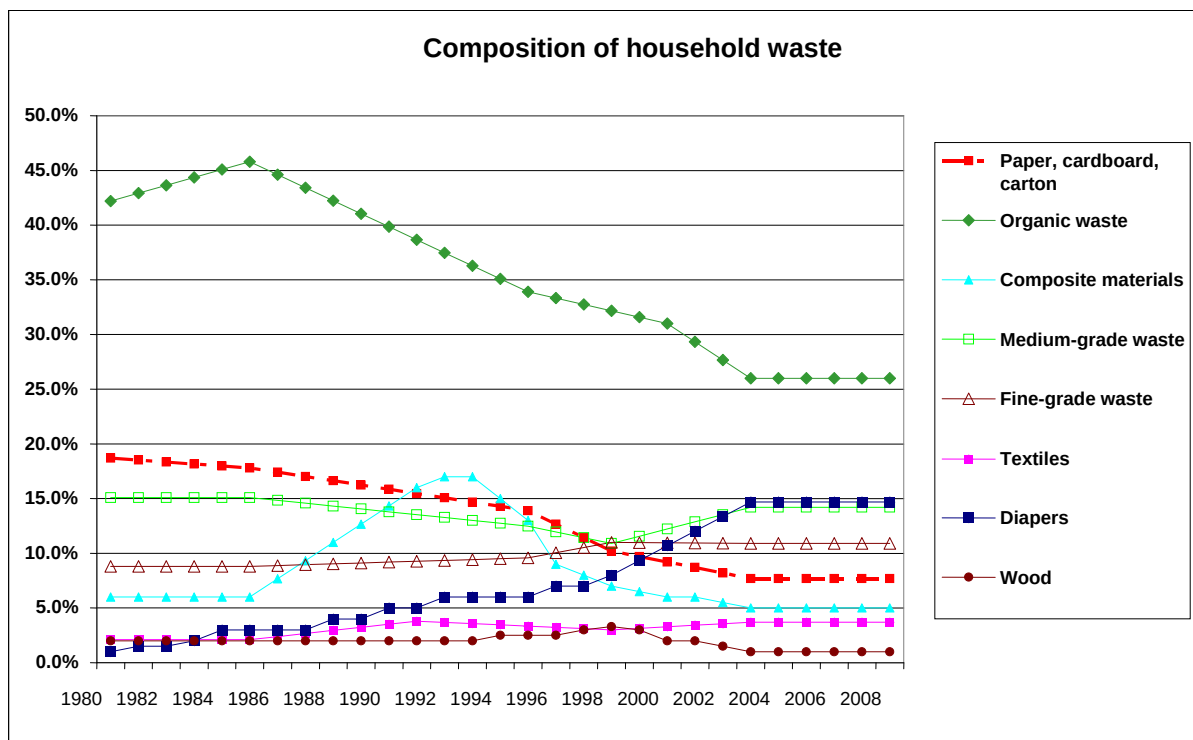


Figure 54: Trends in waste composition (old German Länder) between 1980 and 2000

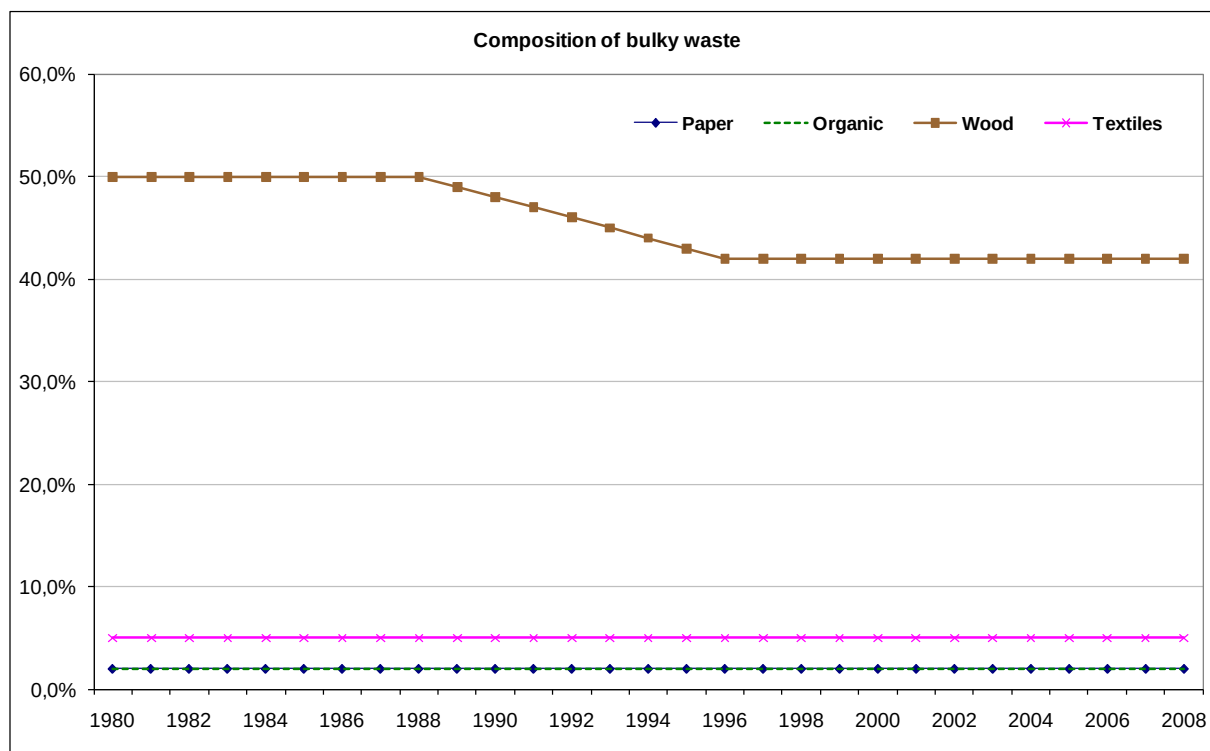


Figure 55: Trends in bulky-waste composition (old German Länder) between 1980 and 2008

Since 1 June 2005 only waste with a total carbon content < 3 %, and mechanically and biologically treated municipal waste, may be landfilled in Germany. Since that time, landfilled waste quantities have decreased very sharply and now make only very small contributions to gas formation. Table 223 outlines the development of quantities of landfilled biodegradable waste.

Table 223: Quantities of biodegradable waste landfilled between 2002 and 2009, broken down by waste fractions

Waste fraction	Units	2002	2003	2004	2005	2006	2007	2008	2009
Organic	1.000 t	2,050	2,227	1,667	785	1	0	0	0
Garden and park waste	1.000 t	186	137	211	160	94	116	134	155
Paper	1.000 t	1,448	1,515	995	499	26	12	9	0
Textiles	1.000 t	336	376	293	135	5	3	2	1
Wood	1.000 t	687	529	438	199	20	24	18	19
Diapers	1.000 t	920	1,215	906	429	0	0	0	0
Diapers + textiles	1.000 t	1,256	1,592	1,199	564	5	3	2	1
Composite materials	1.000 t	379	414	309	146	7	5	4	2
Sewage sludge	1,000 t TM	413	398	348	634	130	129	133	134
Output from MBT facilities	1.000 t	0	0	743	1,092	665	545	616	560

During the 2010 inventory review, the review team requested that CH₄ emissions from landfilled residues from MBT facilities also be included in calculation of emissions from landfilling. While that fraction has now been included, there is no unambiguous method for that waste category, nor are there suitable national parameters for it. Furthermore, no results have yet been obtained with regard to the behaviour of landfilled waste from MBT facilities (i.e. behaviour in real landfills). Only laboratory results have been obtained to date, and thus the results in this area are subject to very high levels of uncertainty. The actual emissions from landfilled waste from MBT facilities are likely to be considerably lower than such laboratory emissions.

In keeping with the recommendations provided in the inventory review 2010 (paragraph 146, FCCC/ARR/2010/DEU), additional information has been provided for the 2011 report. Tabelle

222 shows the per-capita waste quantities landfilled, per day, between 1990 and 2009. Those values do not represent the per-capita waste-production rate that is to be reported, as additional information, in the CRF tables. That figure comprises total waste consumption, taking all waste-management pathways into account. It will be calculated for the next report.

In Germany, landfilling of municipal waste has decreased very sharply since 2005, and that trend is also reflected in the per-capita rate.

Table 224: Per-capita quantities of landfilled household waste

	Units	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Per-capita waste quantity landfilled	kg/capita/day	1,389	0,655	0,284	0,327	0,211	0,226	0,196	0,135	0,031	0,027	0,030	0,029

8.2.1.2.2 *F (Methane-correction factor)*

Until 1972, when the first Waste Act was introduced, waste was usually stored in uncontrolled landfills; such landfills were closed after 1972. After 1972, waste was stored in managed landfills. In keeping with this history, a default MCF value of 0.6 was used for "unclassified landfills" ("nicht zugeordnete Deponien"), while an MCF of 1 was used after 1972.

Data are available from a 1989 survey of the territory of the former GDR that covered 120 managed landfills, some 1,000 controlled storage sites and some 10,000 uncontrolled dump sites (MNUW, 1990). Of the some 13,000 waste-storage sites, a total of 11,000 were for household waste and 2,000 were for industrial waste; most of the latter were plant-owned facilities (BMU, 1990: p. 28). Consequently, an MCF of 0.6 (default value for unclassified landfills) was assumed for the territory of the former GDR for the period 1970 to 1990. Upon German reunification, the Federal Republic of Germany's waste laws were extended to the territory of the new German Länder, and transitional regulations were introduced to ensure that facilities – including both decommissioned facilities and still-operational facilities in which waste was (or is) produced or disposed of – were accounted for and that suitable clean-up measures were initiated (BMU, 1990: p. 46). Uncontrolled landfills were closed in 1990, facilities permitted to remain open were secured, cleaned up and modernised/expanded in keeping with the standards of Federal German waste law, and sites for new facilities were sought. As of 1990, the Federal Statistical Office has collected statistics on both parts of Germany. For purposes of calculation for the period after 1990, an MCF of 1 is used for all of Germany's territory.

8.2.1.2.3 *DOC*

Both national data and IPCC default factors are used for DOC, the proportion of degradable organic carbon in waste. Table 225 provides an overview of the DOC values used.

Table 225: DOC values used

Fraction	DOC	Source
Organic	18%	Various national studies show DOC levels that are higher than the IPCC default value
Garden and park waste	20%	National value
Paper and cardboard	40%	IPCC default
Wood and straw	43%	The national value is somewhat higher than the IPCC default
Textiles	24%	National value
Diapers	24%	National value
Composite materials	10%	National value
Sewage sludge	50%	IPCC default value for sewage sludge, referenced to dry weight
Waste from MBT facilities	2.3%	National value

8.2.1.2.4 DOC_F

DOC_F , the DOC proportion that can be converted into landfill gas, is put at 50 % for municipal waste, on the basis of a national study (RETTENBERGER et al, 1997: p. 277). That value lies within the IPCC default range of 0.5-0.6.

8.2.1.2.5 $F = \text{proportion of } CH_4 \text{ in landfill gas}$

A value of 50%, the mean value in the IPCC default-value range, is assumed for F. That value is based on data of the Federal Statistical Office for the years 2004, 2006 and 2008 (STATISTISCHES BUNDESAMT, Fachserie 19 Reihe 1).

8.2.1.2.6 *Half-life*

The calculation model is a multi-phase model that takes account of the different half-lives for the various different waste fractions. Table 226 shows the half-lives and the methane-production rate used for the pertinent waste fractions. For conformance with the recommendations provided in the inventory review 2010 (paragraph 146, FCCC/ARR/2010/DEU), additional information has been provided for the 2011 report. The constant methane-production rate that appears in the FOD method corresponds to the time required for biodegradable organic carbon in waste to decompose to the point at which it has lost half of its original mass. It thus can be derived from the half-lives of the various relevant fractions, in keeping with Equation 40.

Equation 40: (IPCC 2000 Good Practice Guidance, Chapter 5.1.1.2)

$$k = \ln 2 / t_{1/2}$$

Since the constant methane-production rates, and the half-lives, of the relevant individual waste types are considered separately, in the CRF table "Table6.A,C" the notation key "IE" was used, instead of a universal value.

Table 226: Half-lives and constant methane-production rates of waste fractions

Type of waste	Half-life (years)	CH ₄ -production rate (k value)
Food waste	4	0.173
Garden/park waste	7	0.099
Paper / cardboard	12	0.058
Wood	23	0.030
Textiles / diapers	12	0.058
Composite materials	12	0.058
Sewage sludge	4	0.173
Waste from MBT facilities	12	0.058

8.2.1.2.7 Landfill-gas use

The "TA Siedlungsabfall" of 1993⁷¹ made gas collection one of the prerequisites for licensing of landfills for municipal waste. The amended version of the Environmental Statistics Act (UStatG) of 2005 mandates that in future the Federal Statistical Office, in its surveys, is to take account of, and publish, levels of landfill-gas collection. For the years 2004, 2006 and 2008, data on landfill-gas collection and use were published in Fachserie 19 of 13 June 2010. Those data were collected only from landfills in the landfilling and decommissioning phases, however. To date, such surveys have not taken account of landfills in their after-closure phases.

Use of landfill gas for energy recovery is recorded and reported by the energy sector. Such data include only the energy quantities supplied by landfill operators to third parties, data from which the relevant methane used is calculated after the fact. Landfills' own consumption of energy from landfill-gas collection, at the pertinent landfill sites, and the methane burned in flare systems, without energy use, are not taken into account.

For determination of total quantities of landfill gas collected, it was necessary to combine data from the energy sector and from Fachserie 19. The listed quantity of collected landfill gas includes the landfill gas used for external energy provision, for all landfills; landfills' own consumption of collected gas; and gas quantities flared by landfills in landfilling and decommissioning phases. Landfills' own consumption and flaring losses during their after-closure phases – when landfills have very high landfill-gas-collection rates, because they have surface-sealing covers in place – cannot be quantified at present and taken into account as emissions reductions.

⁷¹ Technical instructions on recycling, treatment and other management of municipal waste (Third general administrative provision on the Waste Act (Abfallgesetz)) of 14 May 1993

Table 227: Methane collection in landfills

	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008
Landfill-gas use for public electricity generation, in keeping with energy data	TJ	9704	9588	9472	9356	11970	13238	14007	14458	14458
Collected landfill gas	Millions of m ³	571	564	557	550	704	779	824	850	850
CH ₄ quantity used for electricity generation	Gg CH ₄	205	202	200	198	253	280	296	305	305
Flared quantities of landfill gas, pursuant to waste statistics	Millions of m ³	70	70	70	70	70	53	37	29	21
Flared quantities of CH ₄	Gg CH ₄	25	25	25	25	25	19	13	10	7
Landfills' own use of landfill gas, for electricity / heat, pursuant to data from waste statistics	Millions of m ³	341	358	375	392	409	414	420	361	302
CH ₄ quantities used by landfills for their own requirements	Gg CH ₄	122	129	135	141	147	149	151	130	108
Total quantity of collected CH ₄	Gg CH ₄	352	356	360	363	425	447	460	445	421

Data on use of sewage gas for energy recovery were not yet available for 2009. For that reason, the methane quantity collected and used in 2009 was considered to be unchanged from 2008. Since the year-to-year changes in the time series for CH₄ collection are small, the resulting error is also low. It will be replaced with a new calculation as soon as the pertinent energy data become available.

8.2.1.2.8 Oxidation factor

As to the factor determining the proportion of CH₄ that is oxidised in landfill covering layers, the IPCC default value of 0.1 was accepted for the entire time series. On the one hand, a larger proportion of uncontrolled landfills can be expected in the former GDR in the early 1990s; on the other hand, a research project found only a low CH₄-formation potential for landfills of the former GDR, and thus the factor 0.1 was also used for that period (BMBF, 1997).

8.2.1.3 Uncertainties and time-series consistency (6.A.1)

The method's uncertainties were estimated for the first time for the NIR 2006. The results of this experts' assessment are presented in the Annex, Chapter 19.6.1.1.

Over the long, 30-year period covered by the activity data, inconsistencies in the time series are unavoidable, since the pertinent waste categories and survey methods changed several times as a result of improvements in legislation and waste statistics. In Germany, special problems arise especially via German reunification and the resulting merging of two different economic and statistical systems. For this reason, considerable effort has to be invested in reviewing data consistency and allocations to the reported categories, in the interest of making time series as consistent as possible.

8.2.1.4 Source-specific quality assurance / control and verification (6.A.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The selected parameters were compared with relevant data for other countries.

The per-capita rate for landfilling of municipal waste (Table 224) was compared with the default value in the Revised 1996 IPCC Guidelines (Table 6-1 in Chapter 6.2.4). For 1995, the default value is in line with the national value. In subsequent years, the national values decreased considerably – and, after 2005, drastically. Those decreases were caused by implementation, in June 2005, of the extensive requirements applying under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (Abfallablagerungsverordnung) and the Landfill Ordinance (Deponieverordnung).

In the area of landfill-gas use, various national data sources were compared and a consistent, conservative approach was selected.

In entry of data, the correctness of entries was checked via sum values – various waste categories were recorded solely for the purpose of checking correctness of data entry.

The national calculation model used to date was reviewed via the IPCC's FOD model – i.e. by entering the same pertinent parameters and data into that FOD model. The same result was obtained.

8.2.1.5 Source-specific recalculations (6.A.1)

No recalculations need to be carried out between the Resubmission 2010 and this year's report. Recalculations on the basis of the in-country review 2010 are presented in Chapter 10.5.2.12. During inventory review in 2010, figures for both CH₄ collection and waste quantities were revised for the years 2006 to 2008. The changes made during the review were applied, in a consistent manner, to 2009

8.2.1.6 Planned improvements (6.A.1)

An experts' assessment (WASTECONSULT INTERNATIONAL, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model.

In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.

8.3 Wastewater handling (6.B)

CRF 6.B					
Key source by level (l) / trend (t) / Tier 2 (T2)		Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend
6.B.2 - Domestic and commercial wastewater	- / t	CH ₄	0.18 %	0.01	-96.4 %
6.B.2 - Domestic and commercial wastewater	- / - / T2	N ₂ O			

The source category *Wastewater handling* is a key category for CH₄ emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-96.4 %), and

thus an extremely low emissions level has been attained (in 2009, emissions amounted to 2.4 % of the contribution of the smallest key source identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key sources.

Under source category 6.B Wastewater handling (treatment), the CSE includes wastewater quantities, treatment of sewage sludge and sewage-sludge production in wastewater treatment.

8.3.1 Methane emissions from industrial wastewater and sludge treatment (6.B.1)

8.3.1.1 Source category description (6.B.1)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NA	NO	NO	NO	NO	NA	NO	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category "Methane emissions from industrial wastewater and sludge treatment" (6.B.1) is a key source only via the aggregated source category Wastewater handling (6.B). No calculations for this source category are carried out at present. In past years, data from municipal wastewater treatment (6.B.2) were listed in the above overview table, due to a transfer error. As a result, 6.B.1 was erroneously listed as a key source.

The composition of industrial wastewater, in contrast to that of household wastewater, varies greatly; it varies by industrial sector. In Germany, the biological stage of industrial wastewater treatment is partly aerobic and partly anaerobic. Anaerobic wastewater treatment is especially useful for industries whose wastewater has high levels of organic loads. That treatment method has the advantages that it does not require large amounts of oxygen, produces considerably smaller amounts of sludge requiring disposal and generates methane that can be used for energy recovery. As in treatment of municipal wastewater, treatment of industrial wastewater releases no methane emissions into the environment. The procedures used include aerobic treatment and anaerobic putrefaction; gas formed in the latter procedure is either used for energy recovery or is flared off. Use for energy recovery is reported under CRF 1.A.1. In both treatment methods, no significant amounts of methane emissions are released into the environment.

Industrial sludge treatment and stabilisation, like industrial wastewater treatment, is carried out either aerobically or anaerobically with methane-gas use.

8.3.2 Municipal wastewater treatment (6.B.2)

8.3.2.1 Methane emissions from municipal wastewater treatment (6.B.2 wastewater treatment)

8.3.2.1.1 Source category description (6.B.2 Wastewater treatment)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)	NA	D/CS	NO	NO	NO	D/CS	NO	NO	NO	NO
EF uncertainties in %		- s. Text				- s. Text				
Distribution of uncertainties		L				L				
EF-determination method		D/CS				D				

The source category *Municipal wastewater treatment* is a key source.

Municipal wastewater treatment in Germany – like that in Sweden and Denmark – uses aerobic procedures (municipal wastewater-treatment facilities, small wastewater-treatment facilities), i.e. it produces no methane emissions (default value for MCF = 0), since such emissions occur only under anaerobic conditions.

Treatment of human sewage from persons not connected to sewage networks or small wastewater-treatment facilities represents an exception: in cesspools and septic tanks, uncontrolled processes (partly aerobic, partly anaerobic) can occur that lead to methane formation. Since 1990, however, organic loads discharged into cesspools and septic tanks have been drastically reduced; the percentages of inhabitants connected to small wastewater-treatment facilities have continually increased. As a result, this sector's CH₄ emissions show a sharply decreasing trend.

8.3.2.1.2 Methodological issues (6.B.2 Wastewater treatment)

Organic loads from cesspools and septic tanks are calculated pursuant to the IPCC method, in which the relevant population is multiplied by the average organic load per person; (cf. Table 228). The average organic load is assumed to be 60 g BOD₅ per inhabitant. This value, the IPCC default value, is used in Germany as a statistical mean value.

Table 228: Organic wastewater load in cesspools and septic tanks

Organic load [BOD ₅ in kt/a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cesspools and septic tanks	180.33	172.45	164.57	156.69	148.80	140.92	105.41	69.90	34.38	31.06
of these, in western Germany	91.69	87.45	83.21	78.97	74.74	70.50				
of these, in eastern Germany	88.65	85.01	81.37	77.72	74.08	70.43				
Organic load [BOD ₅ in kt/a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cesspools and septic tanks	27.74	24.42	23.20	21.98	20.76	19.18	17.59	16.01	14.42	12.84

Numbers in italics: Interpolated and extrapolated figures
(FEDERAL STATISTICAL OFFICE, Fachserie 19, Reihe 2.1, 2009)

Methane emissions from cesspools and septic tanks are determined in keeping with the IPCC method. The IPCC default value for potential methane formation (0.6 kg CH₄/kg BOD₅), and an MCF of 0.5 for cesspools and septic tanks, are assumed. The MCF for cesspools and septic tanks has been estimated on the basis of experience gained in other countries (septic

tanks in the U.S., anaerobically treated municipal wastewater in the Czech Republic (cf. Chapter 19.6.2). The emissions are determined as follows:

$$CH_4(\text{cesspools and septic t.}) = \text{kg } BOD_5 / \text{year} \times 0.6 \text{ kg } CH_4 / \text{kg } BOD_5 \times 0.5$$

Calculation pursuant to Tier 3, as required for key sources, is not feasible, since the substance flows for cesspools and septic tanks are not separately recorded.

Table 229: Methane emissions from cesspools and septic tanks

Methane emissions: [kt CH ₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cesspools and septic tanks	54.10	51.74	49.37	47.01	44.64	42.28	31.62	20.97	10.31	9.32
Methane emissions: [kt CH ₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cesspools and septic tanks	8.32	7.33	6.96	6.59	6.23	5.75	5.28	4.8	4.33	3.85

8.3.2.1.3 Uncertainties and time-series consistency (6.B.2 Wastewater treatment)

Since the uncertainties of the method have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used.

The activity data for organic loads in cesspools and septic tanks are based on data from the Federal Statistical Office's Fachserie 19 Reihe 2.1 that were published in 1991, 1995, 1998, 2001, 2004 and 2007 (*FEDERAL STATISTICAL OFFICE*, Fachserie 19 Reihe 2.1). Every three years, the Federal Statistical Office conducts a survey – without determining the relevant uncertainties – of the numbers of inhabitants who are not connected to the public sewer system and whose wastewater is disposed of via cesspools and septic tanks. No other pertinent data sources are available. The results of such surveys may be considered very precise, since the surveys are complete surveys. For production of a consistent time series, the activity data were linearly interpolated between 1991 and 1995, between 1995 and 1998, between 1998 and 2001, between 2001 and 2004 and between 2004 and 2007. The activity data for 1990, on the other hand, were extrapolated from the 1991-1995 time series. The activity data for 2008 and 2009 were extrapolated from the 2004 to 2007 time series.

Until 1995, data for the old and new Federal Länder were determined separately; since then, a single value for all of Germany has been determined in each case. This does not affect time-series consistency, however.

8.3.2.1.4 Source-specific quality assurance / control and verification (6.B.2 Wastewater treatment)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The MCF for cesspools and septic tanks in Germany was derived on the basis of an evaluation of national inventory reports of other countries (cf. Chapter 19.6.2). No other data sources are available.

The fact that aerobic wastewater treatment in relevant facilities produces no significant methane emissions can be confirmed in other countries (Sweden, Denmark).

8.3.2.1.5 Source-specific recalculations (6.B.2 Wastewater treatment)

Recalculations were carried out for the years 2005-2008 (cf. the table), since the database was updated with Fachserie 19 Reihe 2.1 of 2009.

Table 230: Recalculation of CH₄ emissions from municipal wastewater for the years 2005-2008, and pertinent impacts on greenhouse-gas concentrations

6.B.2 CH ₄ from municipal wastewater	Units	2005	2006	2007	2008
Resubmission 2010	[Gg CO ₂ - equiv.]	123.12	115.43	107.75	100.07
Submission 2011		120.82	110.84	100.86	90.88
Absolute difference		-2.30	-4.60	-6.90	-9.20
Relative difference	[%]	-1.87	-3.98	-6.40	-9.19

In addition, a discrepancy was found, for the years 2006-2008, between the population figures reported in the NIR and the population figures of the Federal Statistical Office that were most recently reported in the CRF Reporter. The reason for the discrepancy is that an alternative population-data source of the Federal Statistical Office (Fachserie 1 Reihe 1.3) was used in emissions calculation in the CSE. The two sources differ by about ½ year in terms of their currentness. The differences between the two sources, and the relevant impacts on emissions, are so small that no need for a detailed discussion is seen at this juncture.

8.3.2.1.6 Planned improvements (6.B.2 Wastewater treatment)

No improvements are planned at present.

8.3.2.2 Methane emissions from municipal sludge treatment (6.B.2 Sludge treatment)

8.3.2.2.1 Source category description (6.B.2 Sludge treatment)

As a general rule, the treatment of municipal sewage sludge comprises two treatment stages:

- Dehydration, using:
Mechanical processes (chamber-filter press, cyclone)
Evaporation in a sludge lagoon or drying beds
- Stabilisation:
Aerobic stabilisation (open pool with oxygen input)
Stabilisation in digestion tower (anaerobic)
Formerly: Open sludge digestion

With respect to population figures, mechanical *dehydration* before and after treatment in the digestion tower currently represents the main treatment method (exception: small sewage-treatment plants in rural areas). Moreover, sewage sludge is generally limed prior to subsequent use, which stabilises it still further.

Sludge stabilisation is carried out in order to prevent uncontrolled putrefaction. In facilities for fewer than 10,000 inhabitants, such stabilisation is usually carried out aerobically, with energy consumption, while in facilities for more than 30,000 inhabitants it normally is carried out anaerobically, with production of methane gas. The amount of methane gas produced depends especially on the composition of the sewage sludge, the temperature and the reaction conditions. Gas so produced is usually used for energy recovery in combined

heat/power generating systems (CHP). It is reported under 1.A.1. Where facilities are unable to use the methane gas cost-effectively in this manner, or when technical disruptions or overloads of attached CHPs occur, the methane gas may be flared off. In both treatment methods, no significant amounts of methane emissions are released into the environment. In the early 1990s in eastern Germany, open sludge digestion was used for sludge stabilisation, a process that produced methane emissions. Open sludge digestion is now no longer used, however. It was phased out gradually, and was then completely discontinued in 1994.

In Germany, sewage sludge from biological wastewater treatment is managed in the following three ways (where applicable, after dehydration and stabilisation):

- Treatment in mechanical-biological waste-treatment facilities: resulting methane emissions are reported in the waste sector.
- Thermal disposal: no methane emissions occur. Thermal disposal requires energy inputs and thus is allocated to CRF 1.
- Recycling for substance recovery: the most important procedures for recycling sewage sludge for substance recovery include recycling in agriculture, pursuant to the Ordinance on Sewage Sludge, and use in recultivation measures and in composting. Emissions from recycling for substance recovery are also not reported under wastewater and sludge treatment.

8.3.2.2.2 Methodological issues (6.B.2 Sludge treatment)

Table 231 lists the emission factors for open sludge digestion and the methane emissions determined for that process.

Table 231: Methane emissions from open sludge digestion, in the new German Länder

	Units	1990	1991	1992	1993	1994
Emission factor	[kg CH ₄ /t TS]	210	210	210	210	210
Sewage-sludge production	[t TS]	247,190	140,952	72,762	37,524	0
Methane emissions	[t]	51,910	29,600	15,280	7,880	0

Emission factors derived from (UBA, 1993)

An emission factor of 210 kg CH₄/t TS is used for open sludge digestion in eastern Germany, in keeping with the results of the study FHG ISI (UBA, 1993: p.15)⁷². The activity data for the years 1990 to 1992 were communicated personally to the Federal Environment Agency by the Chief Inspector of the former GDR's water-processing plants.

In light of the fact that open sludge digestion is prohibited in the Federal Republic of Germany, it was assumed that use of that treatment method was gradually reduced in the new German Länder until 1994 and was no longer used at all as of 1994.

8.3.2.2.3 Uncertainties and time-series consistency (6.B.2 Sludge treatment)

Since the uncertainties of the method have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used. The activity data between 1990 and 1992 are based on a personal communication; those for 1993 are based on estimates of the Federal Environment Agency. As a result, a high degree of time-series consistency is not assured.

⁷² The emission factor was determined via the difference between methane emissions from psychrophilic sludge stabilisation in the new German Länder and the total amount of sewage sludge produced.

8.3.2.2.4 *Source-specific quality assurance / control and verification (6.B.2 Sludge treatment)*

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.3.2.2.5 *Source-specific recalculations (6.B.2 Sludge treatment)*

No recalculations are required.

8.3.2.2.6 *Planned improvements (6.B.2 Sludge treatment)*

At present, improvements seem neither necessary nor possible, since no further activity data can be obtained.

8.3.2.3 *Nitrous oxide emissions from municipal wastewater (6.B.2 Nitrous oxide emissions from municipal wastewater)*

8.3.2.3.1 *Source category description (6.B.2 Nitrous oxide emissions from municipal wastewater)*

Nitrous oxide (laughing-gas) emissions can occur as a by-product of municipal wastewater treatment, especially in connection with denitrification, in which gaseous end products – mainly, molecular nitrogen, however – are formed from nitrate (AUST, n.y.).

The emissions trend is stable stagnation.

8.3.2.3.2 *Methodological issues (6.B.2 Nitrous oxide emissions from municipal wastewater)*

Pursuant to the IPCC method, nitrous oxide emissions from household wastewater can be roughly determined via the average per-capita protein intake. The IPCC default values are used in each case for the nitrous-oxide emission factor per kg of nitrogen in wastewater, and for the nitrogen fraction in protein; the average per-capita protein intake and relevant population figures for Germany have to be determined on a country-specific basis.

The FAO's figures are used for determination of the average protein intake per person and day:

- For Germany and for the years 1989-91, the FAO gives an average protein intake per person and day of 98g (cf. Table 232).⁷³
- In keeping with the FAO Statistical Yearbook 2007 – 2008⁷⁴ average protein intakes, per person and day, of 95 g (1994 – 1996), 97 g (1999 – 2001) and 99 g (2003 – 2005) are given for Germany (cf. Table 232).

73 FAO Statistical Yearbook 2004 Vol.1/1 http://www.fao.org/statistics/yearbook/vol_1_1/index.asp; September 2007

74 FAO Statistical Yearbook 2007-2008 table D.1; <http://www.fao.org/economic/ess/publications-studies/statistical-yearbook/fao-statistical-yearbook-2007-2008/d-consumption/en/>; August 2009

Table 232: Daily protein intake per person in Germany

	[g/inhabitant and day]									
Protein intake	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	98	98	97	96	95	95	95	96	96	97
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	97	97	98	99	99	99	99	99	99	99

Numbers in italics: Extrapolated or automatically extended values
(FAO, FAO statistical yearbook 2004 & 2007 – 2008)

Table 233: Population in Germany

	[in thousands]									
Inhabitants	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	79,753	80,275	80,975	81,338	81,539	81,817	82,012	82,057	82,037	82,163
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	82,260	82,440	82,537	82,532	82,501	82,438	82,315	82,218	82,002	81,802

(FEDERAL STATISTICAL OFFICE, Statistisches Jahrbuch 2010)

The nitrous oxide emissions can be determined with the aid of Table 232 and Table 233 and the IPCC method; cf. Table 234.

$$N_2O_{(s)} = Protein \times Frac_{NPR} \times NR_{PEOPLE} \times EF_6$$

where:

$N_2O_{(s)}$ = N_2O emissions from human wastewater (kg N_2O – N/a)

Protein = annual protein intake (kg/person/a)

NR_{PEOPLE} = Population of the country

EF_6 = emission factor (default 0.01 (0.002–0.12) kg N_2O – N/kg produced wastewater – N)

$Frac_{NPR}$ = Nitrogen fraction in protein (default = 0.16 kg N/kg protein)

Table 234: Nitrous oxide emissions in Germany pursuant to IPCC method

	[t N_2O]									
N_2O emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	7,173	7,220	7,208	7,166	7,109	7,133	7,150	7,204	7,253	7,314
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	7,323	7,339	7,423	7,498	7,496	7,490	7,479	7,470	7,450	7,432

8.3.2.3.3 Uncertainties and time-series consistency (6.B.2 Nitrous oxide emissions from municipal wastewater)

Since the uncertainties for emissions determination have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used. The activity data for 1989-1991 were taken from the Statistical Yearbook 2004. The data for 1994-1996 and 1999-2001, and for 2003-2005, were taken from the FAO Statistical Yearbook 2007-2008 Table D.1. The values for 1992 and 1993 are equivalent to the arithmetic mean of 1991 + 1994; the values for 1997 and 1998 are equivalent to the arithmetic mean of 1996 + 1999; the value for 2002 is equivalent to the arithmetic mean of 2001 + 2003. The activity data as of 2006 are extrapolations of the data for 2005 published in the FAO Statistical Yearbook 2007/2008.

Since the population-specific activity data increased by only about 4 % within 10 years (1995 – 2005), the error for the extrapolation as of 2006 is, at most, of the same order.

Calculations were based on the average daily protein requirements listed by the FAO database, to ensure that the time series is consistent and to prevent any need for extrapolation of individual values.

8.3.2.3.4 *Source-category-specific quality assurance / control and verification* **(6.B.2 Nitrous oxide emissions from municipal wastewater)**

Quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

Analysis of the national inventory reports of other countries shows that most Annex I countries, like Germany, use the IPCC method for determining N₂O emissions.

Alternative data sources for the average protein intake per person and day include:

- The 1991 food table for practical applications (SENSER et al, 1991) lists an average protein intake of 94 g/inhabitant and day.
- The nutrition report of the German Nutrition Association (Deutsche Gesellschaft für Ernährung - DGE, 2000)⁷⁵ used estimated food-consumption data for 1993 to estimate average daily protein intake (among other figures). From that data, an average value of about 76.5 g protein / person and day⁷⁶ was derived.

The FAO database in the Statistical Yearbooks 2004 (Vol.1/1) and 2007–2008 (table D.1) is used as a basis for determination of N₂O emissions from wastewater, since those sources constitute a consistent time series. It is internationally comparable, and it is regularly updated. In addition, the FAO has declared that the new Yearbook for 2007-2008 supplants the previous four FAO yearbook publications. The Federal Environment Agency has no information to the effect that the country-specific values in the food table and in the 2000 nutrition report are more precise or enjoy greater national acceptance. In addition, many countries use the FAO database; as a result, the emissions-determination process used by Germany is internationally comparable. An international comparison shows that the daily protein intake assumed for Germany lies within the middle of the overall range.

8.3.2.3.5 *Source-specific recalculations (6.B.2 Nitrous oxide emissions from municipal wastewater)*

A discrepancy was found, for the years 2006-2008, between the population figures reported in the NIR and the population figures of the Federal Statistical Office that were most recently reported in the CRF Reporter. The reason for the discrepancy is that an alternative population-data source of the Federal Statistical Office (Fachserie 1 Reihe 1.3) was used in emissions calculation in the CSE. The two sources differ by about ½ year in terms of their currentness. The differences between the two sources, and the relevant impacts on emissions, are so small that no need for a detailed discussion is seen at this juncture.

75 The nutrition report is published every four years.

76 This value was obtained with the help of the rough estimate that each population group in Germany consists of 50% men (81.5 g/day) and 50% women (71.6 g/day).

8.3.2.3.6 *Planned improvements (6.B.2 Nitrous oxide emissions from municipal wastewater)*

No improvements are planned at present.

8.4 Waste incineration (6.C)

All waste incineration in Germany is carried out with energy recovery; for this reason, and in order to avoid double counting, the resulting emissions are reported in the energy section (CRF 1). No emissions (NO) from this energy use, therefore, are reported under 6.C.

8.5 Other areas (6.D)

In source category 6.D, emissions from composting systems (6.D.1) and from mechanical-biological waste treatment (6.D.2) are reported.

CRF 6.D					
Key source by level (l) / trend (t) / Tier 2 (T2)	Gas (key source)	1990 – contribution to total emissions	2009 – contribution to total emissions	Trend	
--	--				

8.5.1 Other areas – composting facilities (6.D.1)

8.5.1.1 Source category description (6.D.1)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)		CS				CS				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		T1/CS				T1/CS				

In Germany, annually increasing fractions of biodegradable waste are being managed in composting facilities. For this reason, the 2006 inventory included a first report on CH₄ and N₂O emissions from composting of municipal waste in composting facilities, along with a complete time series for these emissions. This category does not include composting of garden and household plant waste by households, in their own gardens. Such emissions are considered negligible, and no data regarding the relevant composted quantities are available.

8.5.1.2 Methodological issues (6.D.1)

Neither the "1996 IPCC Guidelines for National Greenhouse Gas Inventories" nor the IPCC report on "Good Practice Guidance" (2000) present any methods for calculating emissions from kitchen-waste composting. For this reason, a national method has been developed in which composted waste quantities are multiplied by emission factors from a national study (see below).

Activity data

Since 1980, the Federal Statistical Office has regularly collected and published data on waste quantities managed in composting facilities. Since 2000, data on pertinent inputs of kitchen waste and plant waste (garden and park waste), and on waste inputs in composting and fermentation facilities, have been separately collected and published.

The activity data for the current report year have to be estimated, since official waste statistics are published with a one-year time lag. For purposes of estimation, the waste-quantity figure from the previous year is used, unchanged.

Table 235: Quantities of waste placed in composting facilities

[in 1000 t]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Waste quantity	724	1,515	1,956	2,397	3,783	5,168	6,554	7,214	7,320	7,964
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Waste quantity	9,030	9,244	9,459	9,304	9,191	9,207	8,960	9,329	9,089	9,089

Emission factors

A research project carried out under commission to the Federal Environment Agency (IFEU 2003a) derived a method for calculating emission factors for the substances CH₄, N₂O and NH₃ from composting. The relevant database was provided by a study of Deutsche Bundesstiftung Umwelt (DBU 2002). In the pertinent method for determination of emission factors, average concentrations of carbon and nitrogen in kitchen waste and plant waste were assumed. In addition, estimates were made of the average decomposition rates during composting, as well as of distribution of carbon and nitrogen throughout the relevant emitted decomposition products.

For kitchen waste from households, the following emission factors resulted:

$$\begin{aligned} \text{EF-N}_2\text{O} &= 83 \text{ g N}_2\text{O/Mg kitchen waste} \\ \text{EF-CH}_4 &= 2.5 \text{ kg CH}_4/\text{Mg kitchen waste} \end{aligned}$$

For plant waste, the same study obtained the following emission factors:

$$\begin{aligned} \text{EF-N}_2\text{O} &= 60.3 \text{ g N}_2\text{O/Mg plant waste} \\ \text{EF-CH}_4 &= 3.36 \text{ kg CH}_4/\text{Mg plant waste} \end{aligned}$$

These national emission factors were used for the inventory calculations.

8.5.1.3 Uncertainties and time-series consistency (6.D.1)

Activity data

The uncertainties for the composted waste quantities are considered very small (2 %), since the relevant data were obtained via a complete-coverage survey, the reporting quality is good and operators have an interest in high-quality reporting.

Emission factors

The uncertainties for the emission factors are high. They depend on the type of facility/plant in question, on waste composition and on the effectiveness of the biofilters used. The pertinent figures from the literature and from other countries vary so widely that uncertainties of +60 % to -30 % for CH₄, and of at least +100 % to -50 % for N₂O, are assumed.

8.5.1.4 Source-specific quality assurance / control and verification (6.D.1)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.5.1.5 Source-specific recalculations (6.D.1)

Recalculations have to be carried out annually for the year prior to the previous year. For this NIR, recalculations have to be carried out for 2008, since the activity data of the Federal Statistical Office appear with a one-year time lag and thus the current report-year data have

to be estimated. In each case, such estimates are replaced in the following year with the relevant figures from survey statistics.

8.5.1.6 Planned improvements (6.D.1)

Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH₄ and N₂O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. This project, when completed, is expected to yield new emission factors for both gases.

8.5.2 Other areas – mechanical-biological waste treatment (MBT) (6.D.2)

8.5.2.1 Source category description (6.D.2)

Gas	CO ₂	CH ₄	HFC	PFC	SF ₆	N ₂ O	NO _x	CO	NMVOC	SO ₂
Emission factor (EF)		CS				CS				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		T1/CS				T1/CS				

As of 1 June 2005, direct landfilling of organic and biodegradable waste is no longer permitted in Germany. Miscellaneous municipal waste, and other waste of similar composition, may thus be landfilled only following pre-treatment. In addition to thermal waste-treatment processes (waste incineration), mechanical-biological processes are increasingly being used for this purpose.

Since the 1990s, mechanical-biological processes have been used extensively in Germany for managing miscellaneous waste. Initially, relevant plants had relatively simple designs and were not fitted for waste-gas collection and treatment. As processes have improved, however, closed systems, with "biofilters" for waste-gas scrubbing, have gradually become the norm. While the waste-gas-scrubbing processes used by such plants have significantly reduced the plants' smell emissions, they have not reduced greenhouse-gas emissions.

In 2005, when all landfilling of untreated waste was terminated, capacities for mechanical-biological waste treatment were considerably expanded. Pursuant to the 30th Ordinance on the Execution of the Federal Immission Control Act (30th BImSchV), as of 1 March 2001, new plants for mechanical-biological waste treatment must fulfil strict technical requirements and conform to demanding standards for maximum permitted emissions. The transitional provisions for old plants call for such plants to be retrofitted by no later than 1 March 2006.

Nearly all recently constructed new facilities were commissioned in 2005. Nearly all old facilities were brought into conformance with the 30th BImSchV in 2005, via expansions and operational upgrades. The transitional situation prevailing in 2005 can hardly be described with existing calculation models, since the relevant waste quantities cannot be correlated with the various relevant facility technologies. For the sake of simplicity, emissions through the year 2005 are calculated with the higher emission factors applying to the older-facility systems. For 2006, emissions are being calculated using the lower emission factors for the new facilities.

8.5.2.2 Methodological issues (6.D.2)

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems. For the years 2007 through 2009, data from the research project "Facilities for mechanical-biological treatment of residual waste" ("Anlagen zur mechanisch-biologischen Restabfallbehandlung"; UBA, 2007) were used, since the pertinent data of the Federal Statistical Office contained inconsistencies that could not be eliminated. The data of the *Federal Statistical Office* do not cover all facility types that, in terms of their emissions behaviour, are similar to MBT facilities. For example, the data do not include waste quantities treated in mechanical-biological stabilisation (MBS) facilities. Pursuant to data of the Federal Statistical Office, in 2008 3.9 million Mg/a of waste were treated mechanically and biologically. The corresponding figure obtained by the research project is 4.9 million Mg/a. To prevent any underestimation of greenhouse-gas emissions from MBT facilities, emissions are calculated on the basis of the higher waste-quantity figures obtained by the research project.

Activity data

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems. For 2007, data from the research project "Facilities for mechanical-biological treatment of residual waste" ("Anlagen zur mechanisch-biologischen Restabfallbehandlung"; UBA, 2007) were used, since the pertinent data of the Federal Statistical Office contained inconsistencies that could not be eliminated.

Emission factors

In the 1990s, emissions from mechanical-biological waste treatment were studied in a major collaborative research project supported by the Federal Ministry of Education and Research (BMBF). In a project carried out in 2003, the Institute for Energy and Environmental Research (IFEU) used the collaborative research project's findings to develop emission factors. In doing so, it differentiated between mechanical-biological waste-treatment processes that were open (with no waste-gas collection and treatment) and processes that were closed (with waste-gas collection and treatment in biofilters). For methane, the emission factors for both types of processes were considered to be the same, since that substance is hardly broken down at all in biofilters. The N₂O emission factor for closed systems was considered to be higher than that for open systems, since N₂O also forms in biofilters, via oxidation of ammonia nitrogen.

Since June 2005, as a result of new legal provisions (30th BImSchV), all mechanical-biological waste-treatment facilities are closed facilities, which have the more effective waste-gas-scrubbing processes. As of 2006, therefore, the emissions standards of the 30th BImSchV will be used as the emission factors for this area.

For open mechanical-biological waste-treatment facilities, the following emission factors resulted:

EF-N₂O = 190 g N₂O/Mg waste
EF-CH₄ = 150 g CH₄/Mg waste

For closed mechanical-biological waste-treatment facilities with biofilters, the same study obtained the following emission factors:

EF-N₂O = 375 g N₂O/Mg waste
EF-CH₄ = 150 g CH₄/Mg waste

For the period as of 2006, the emissions-load limitations imposed by the 30th BImSchV will be used as the applicable emission factors:

EF-N₂O = 100 g N₂O/Mg waste

EF-CH₄ = 55 g CH₄/Mg waste

Since in 2005 most MBT systems were equipped with waste-gas-treatment systems for minimising N₂O emissions, the emission factor for 2005 was estimated to be 169 g.

These national emission factors were used for the inventory calculations.

8.5.2.3 Uncertainties and time-series consistency (6.D.2)

The uncertainties for the mechanically-biologically treated waste quantities are considered to be very small (2 %) theoretically, since the relevant data were obtained via a complete-coverage survey, the reporting quality is good and operators have an interest in quality reporting. Nonetheless, it will be necessary, in order to rule out any possibility of underestimation of waste quantities, to consult with the Federal Statistical Office to determine which versions of "cold" waste-treatment processes are assigned to the MBT category. The uncertainties for the emission factors are high for the period before 2005. They depend on the type of facility/plant in question, on the type of process used at the relevant time and on the effectiveness of the biofilters used. The pertinent figures from the literature vary widely. For the period after 2005, it may be assumed that emissions easily comply with the standards of the 30th BImSchV or are even much lower than those standards. The only uncertainties are found in the question of the extent to which emissions during actual plant operations lie below the standards.

8.5.2.4 Source-specific quality assurance / control and verification (6.D.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.5.2.5 Source-specific recalculations (6.D.2)

No recalculations were required.

8.5.2.6 Planned improvements (6.D.2)

The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date.

9 OTHER (CRF SECTOR 7)

At present, no greenhouse gas emissions are calculated for Germany which cannot be allocated to one of the existing source categories.

10 RECALCULATIONS AND IMPROVEMENTS

In the following section, recalculations based on quantitatively effective inventory improvements are documented that occurred between the inventory calculations for the 2009 report year and those for the 2011 report year. Further information regarding the recalculations is provided in CRF tables 8(a) and 8(b) and in the present report's chapters on source-specific recalculations.

Pursuant to the aims of the *Good Practice Guidance*, emissions calculations should be based on the best available data, and efforts should be made to improve the inventories continuously, resulting in annual recalculations. For example, recalculations become necessary when statistics are updated retroactively and the relevant changes are adopted in the inventories. Recalculations are also required when more precise data are included, when manual-transfer errors are corrected and when key-source analysis reveals a need to change methods for individual source categories. In addition, a range of factors in specialised/technical areas can necessitate recalculations.

The recalculations are thus based on the inventory data provided with the Resubmission 2010. The data in the Submission 2010, on the other hand, are not the subject and basis of the following considerations; they should be seen as obsolete.

Since no inventory report is available for the Resubmission 2010, the recalculations made between the now-obsolete Submission 2010 and the Resubmission 2010, recalculations on which the described recalculations are based, are described in Chapter 10.5 separately.

10.1 Explanation and justification of the recalculations

10.1.1 Greenhouse-gas inventory

10.1.1.1 General procedure

There are a number of other reasons, in addition to the need for corrections, why recalculations and improvements can be necessary:

- Additional data become available that makes it possible to close gaps in the inventory.
- A data source has changed.
- A method used for a source category has been adapted to provisions of the Good Practice Guidance.
- A source category has become a key source, thus necessitating a change of methods.
- New country-specific calculation procedures need to be used.
- Recommendations and results provided by reviews have been implemented.

In good practice, when methods change, the entire relevant time series should be consistently recalculated with the same method, to ensure that the same method is used each year and old values can be suitably replaced. Where the same method cannot be used every year, one of the following four recalculation procedures (IPCC Good Practice Guidance, 2000: Chapter 7) should be used:

- Overlapping procedure: For this method, the data for calculation pursuant to the old and new methods should be jointly available for at least one year.
- Replacement procedure: For this method, the EF and/or AD used to date should be highly similar to the newly available data.

- Interpolation procedure: The data previously used for recalculation cover only a few years of the time series, and the lacking data are interpolated.
- Extrapolation procedure: The data for the new method are not available for the beginning and/or end of the time series.

The QSE manual contains a guide to the above-outlined recalculation procedures. It also presents relevant examples.

10.1.1.2 Recalculations in the 2011 report year, by source categories

This year's recalculations were necessitated by a range of methodological adjustments, some which led to significant changes in the affected source categories (especially CRF 4 and 5), as well as by further improvements in details.

The inventories contain improvements in the following areas:

Energy (selection):

- With regard to activity data most recently used for 2008, transition from the evaluation tables to the Energy Balance (1.A)
- Updating of limestone inputs in flue-gas scrubbing (1.A1.a)
- Comprehensive recalculations following transition to Tier 3 (1.A.3.a, 1.C.1.a)
- Revision of the split factor for determining national air traffic as a share of total air traffic, 1990-2002 (1.A.3.a, 1.C.1.a)
- Cross-checking of activity data against Energy Balance figures (1.A.3.a, 1.C.1.a)
- First-time inclusion of co-combusted lubricants (1.A.3.a)
- Updating (as of 1995) of the TREMOD software (currently, Version 5.11 is being used) (1.A.3.b)
- Updating of activity data for consumption of LP gas, for 2008 (1.A.3.b)
- Use of updated Energy Balance figures for consumption of diesel fuel (2008) and biodiesel (as of 2006: transition from calculated values to Energy Balance values) (1.A.3.c).
- First-time inclusion of co-combustion of lubricants in inland shipping (1.A.3.c, 1.A.3.d)
- Use of extrapolated activity data for consumption of diesel fuel and biodiesel in inland shipping, due to relevant errors in Energy Balances (2007-2009) (1.A.3.d)
- Transition from calculated values to Energy Balance values for consumption of biodiesel (only for 2006) (1.A.3.c).
- Adaptation of EF(CH₄) to relevant values in TREMOD and TREMOD-MM (as of 1995) (1.A.3.c, d, e ii & 1.A.4.c ii)
- First-time inclusion of emissions from national deep-sea fishing (1.A.4.c iii)
- First-time inclusion of CO₂ emissions from co-combusted lubricants (1.A.5.b)
- New findings in the area of storage of petroleum and petroleum products, with regard to CH₄ and NMVOC emissions (1.B.2.a vi)
- Use of more specific EF(CH₄) and EF(NMVOC) for emissions from transfer of petrol at petrol stations (1.B.2.a v)
- New inclusion of flare emissions in refineries, via a new EF(CO₂) (1.B.2.c)

Industrial processes:

- Existing EF(CO₂) for methanol replaced with IPCC default value (670 kg CO₂/t, IPCC-GL 2006) (2.B.5)
- Change in the EF(SF₆) for aluminium foundries as of 1999 (2.C.4)

- Change in emissions from household refrigeration appliances (via changes in applicable lifetimes and in emissions from disposal) (2.F.1.a)
- Correction in the number of refrigerated containers produced globally in 2008 (2.F.1.c)
- Adaptation of the emissions from disposal of large stationary air-conditioning systems (2.F.1.e)
- Correction of the emissions data for heat pumps, as a result of revision of the applicable calculation procedure (2.F.1.e)
- Changes in emissions data for air-conditioning systems in/on busses, agricultural machinery, ships, utility vehicles and rail vehicles, in keeping with new findings. (2.F.1.f)

Solvent and other product use:

- Recalculation of NMVOC emissions on the basis of a research project (3.A-D)
- Change in indirect CO₂ emissions as a result of new use of the reference approach in the 2006 IPCC GL (3.A-D)
- Reduction of the EF(N₂O) for explosives, from 3.4 to 0.1036 kg N₂O/t explosives, in keeping with new measurements (3.D)
- Recalculation of the N₂O emissions from whipped-cream aerosol cans, using new data (3.D)
- Change in N₂O-emissions data for the area of anaesthesia, on the basis of new data provided by the industrial-gas association (3.D)
- Change in N₂O emissions from the semiconductor industry, on the basis of new data provided by the German Electrical and Electronic Manufacturers' Association (ZVEI) (3.D)

Agriculture (selection):

- Cattle counts for the period as of 2008 are taken from the HIT database, which includes every relevant animal (for the period until 2007, corresponding figures will continue to be taken from official statistics, which, as a result of cutoff limits, do not include every relevant animal) (4.A, 4.B)
- Decision not to correct horse head counts as of 1999 and sheep head counts for the period 1990 to 1998 (4.A, 4.B)
- Updating of the time series for the various relevant housing systems for laying hens, for the period 1990 to 2009 (4.B)
- Changes in calculation of total energy intake for dairy cows, fattening bulls, suckling cows and fattening swine, with impacts on excretions (4.A)
- Correction of an error, applicable to all solid-manure housing systems, in calculation of TAN immobilisation in stalls (4.B., 4.D)
- Change in the impact of grazing on the breakdown of excretions into stall excretions and grazing excretions, for horses, mules and asses (4.B)
- Inclusion of current data relative to cleaning periods between fattening cycles, for broilers (4.B)
- Return to the procedure pursuant to the IPCC 1996 Guidelines for calculation of N₂O emissions as a result of manure application (4.D)
- Updating of the database for yields from meadows, mowed pastures and field-fodder cultivation (4.D)

- Revision of the method for calculating soil N losses resulting from surface runoff and leaching (preceding N losses via emissions of N species are now taken into account) (4.D)

Land use, land-use changes and forestry:

- Recalculation of carbon-stock changes in biomass, for forest land remaining forest land, for new forest land and for deforestation (5.A.1, 5.A.2, 5.B.2.1-5.F.2.1)
- First inclusion of carbon emissions from litter, for forest land remaining forest land (5.A.1)
- Recalculation of carbon-stock changes in litter, for new forest land and deforestation (5.A.2, 5.B.2.1-5.F.2.1)
- First estimation of emissions from "dead organic substance", for the period as of 1990 (CRF 5)
- Complete recalculation of the data for 5.B – 5.F
- Recalculation of data for N₂O releases as a result of land-use changes resulting in cropland (5 (III))

Waste and wastewater:

- Updating of the database for the period 2005-2008, on the basis of the Federal Statistical Office's Fachserie 19 Reihe 2.1 from 2009 (6.B)
- Correction of a discrepancy in population figures, for the years 2006-2008, between the NIR and the CRF tables (6.B, 6.B.2)

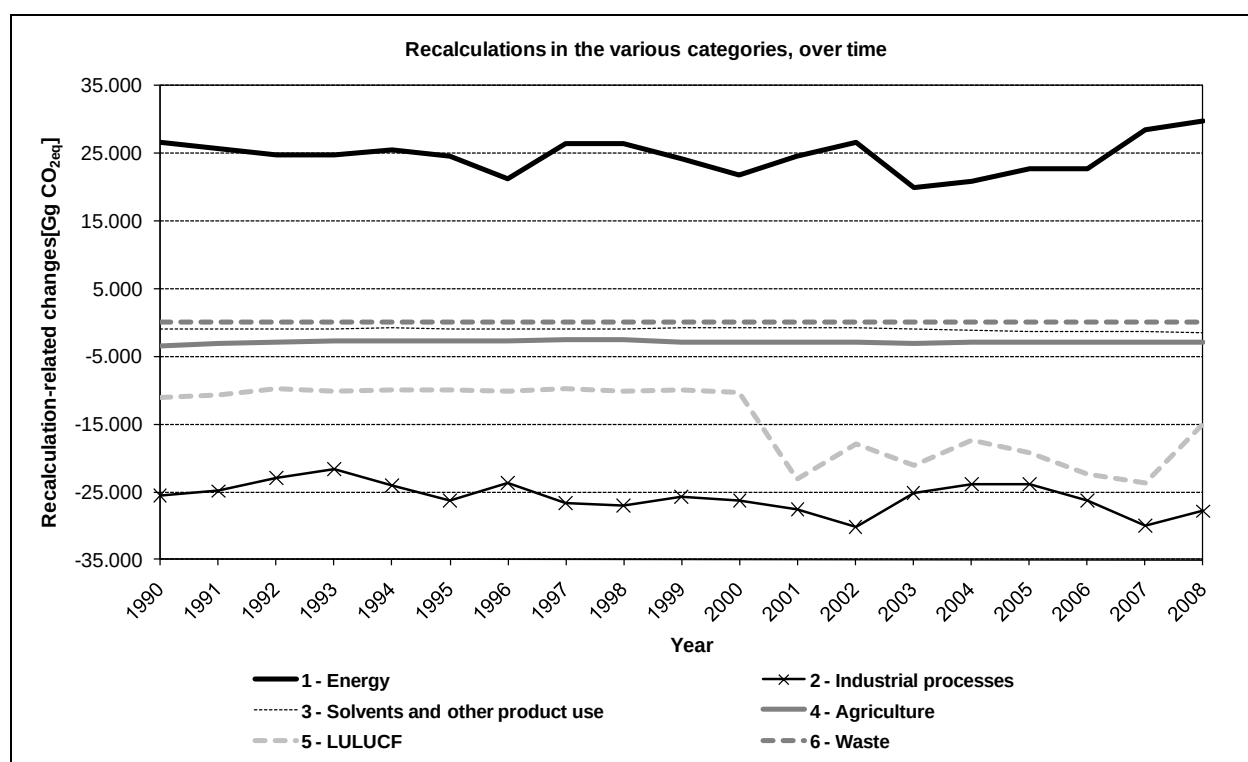


Figure 56: Change in total emissions, for all categories, and for the entire time series, in comparison to the relevant figures in the Resubmission 2010

10.1.1.3 Recalculations in the 2011 inventory, by gases

Recalculations were carried out in the following source categories (in each case, cf. the specifications under 10.1.1.2):

Table 236: Source categories in which new recalculations of the inventory, with regard to last year's report, were required

CRF	CO ₂	CH ₄	N ₂ O	F gases
1 – Energy	X	X	X	
2 – Industrial processes	X			X
3 – Solvent and other product use	X		X	
4 – Agriculture				
5 – LULUCF	X	X	X	
6 – Waste & wastewater			X	

Table 237: Inventory recalculations with respect to last year's report

	Base year (1990/ 1995)	2008
	Change in [%]	
Total (CO _{2eq})	-0.21%	-0.27%
CO ₂	0.03%	0.50%
CH ₄	0.11%	-0.50%
N ₂ O	-3.44%	-5.61%
HFC, PFC, SF ₆	0.00%	-14.31%

Source: own calculations; emissions do not include LULUCF

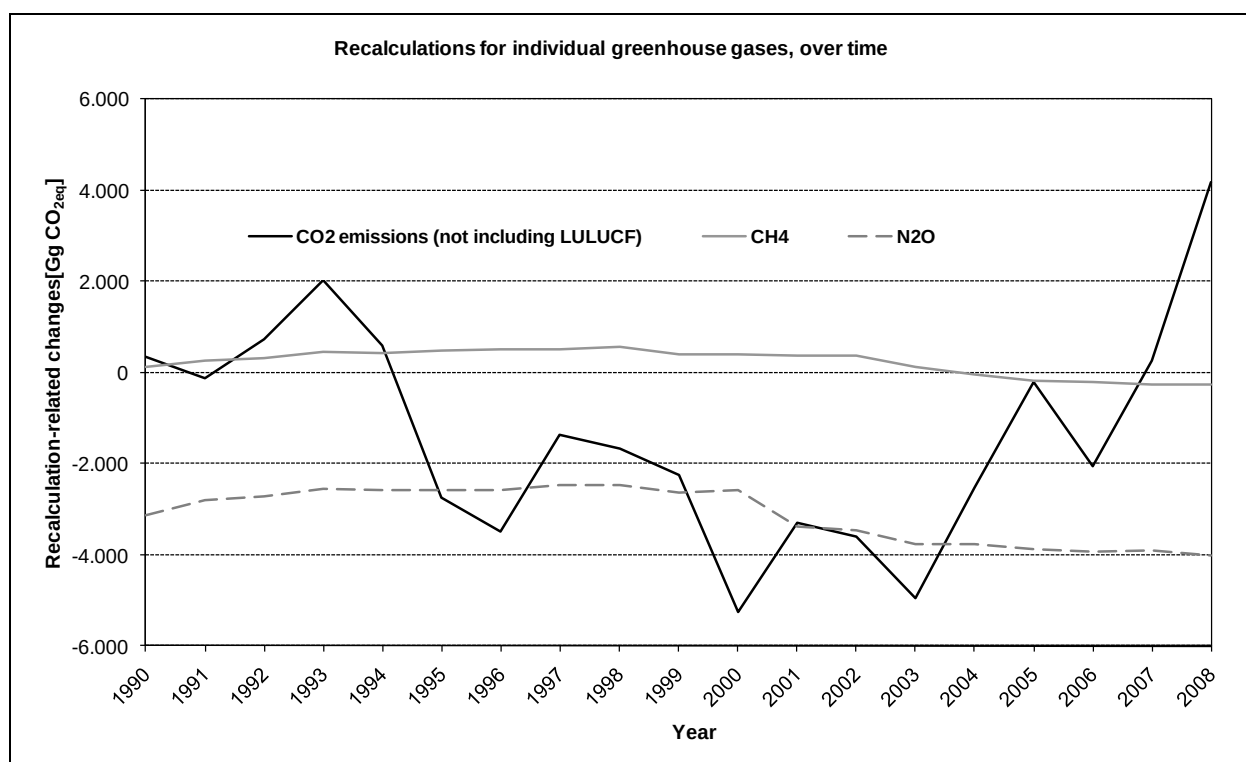


Figure 57: Recalculations of pollutant-specific total emissions, for all source categories, and for the entire time series, in comparison to the relevant figures in the Resubmission 2010

10.1.1.4 Recalculations carried out to implement results of the review process

The following section takes account solely of recalculations that were not yet included in the Resubmission 2010 (which resulted from the In-Country Review 2010), i.e. which were not part of the Saturday Letter.

With respect to that Resubmission, which serves as the database for the recalculations described in the present section, only minor, Review-based, recalculations for the purpose of recalculations were carried out:

- Recording of CH₄ and N₂O emissions from co-combusted lubricants (mobile sources) as "IE" (included elsewhere) rather than "NE" (not estimated), in keeping with the assumption that co-combustion of lubricants is already included in the EF for the (liquid) fuels used in the relevant source categories.
- Nitrous oxide emissions from flaring in oil and natural gas extraction and in natural gas processing (1.B.2.b and 1.B.2.c).
- The land-area matrix was recalculated for the entire LULUCF sector (5.A-5.F)
- Carbon losses from organic soils were recalculated for new forest land (5.A.2)

10.1.2 KP LULUCF inventory

10.1.2.1 General procedure

The methods used for recalculations under the Kyoto Protocol are the same as those used under the Convention. Detailed information on the general procedure is provided in Chapter 10.1.1.1.

10.1.2.2 Recalculations/recalculations in the 2010 report year, by source categories

- Recalculation of carbon-stock changes in biomass in managed forests, on afforested land and on deforested land (KP 3.4, KP 3.3)
- First inclusion of carbon emissions from litter, for managed forest land (KP 3.4)
- Recalculation of emissions from liming in managed forests (KP 3.4)
- Recalculation of carbon-stock changes in forest-floor litter, on afforested land and deforested land (KP 3.3)

10.1.2.3 Recalculations in the 2010 inventory, by gases

CO₂-based recalculations were carried out for biomass, litter and liming. No recalculations were carried out with respect to the gases CH₄ and N₂O.

10.1.2.4 Recalculations carried out to implement results of the review process

- The land-area matrix was recalculated for the entire KP-LULUCF sector (KP 3.3, KP 3.4)
- Carbon losses from organic soils were recalculated for afforested land (KP 3.3)

10.2 Impact on emissions levels

10.2.1 Greenhouse-gas inventory

As a result of the In-Country Review that immediately preceded the Submission 2011, and of the Resubmission 2010 (with a range of recalculations, some of them considerable), the changes with respect to the basis for comparison, which was completely revised via the Resubmission 2010, are very small when seen with respect to the entire inventory: -0.21 % in 1990 and -0.27 % in 2008. The largest change in this connection, -0.91 %, occurred in the greenhouse-gas emissions reported for the year 2003.

With respect to the Resubmission 2010, total emissions are reduced – although only slightly. The reduction is due primarily to the recalculations carried out in the categories CRF 3 – *Solvents* and CRF 4 – *Agriculture*.

In addition, transfer of CO₂ emissions from combustion of blast furnace gas in power stations and boilers, from CRF 2 to CRF 1, led to absolute changes that nearly cancel each other out and thus have only a small influence on the inventory as a whole.

The inventory has been considerably improved with regard to completeness and accuracy.

Table 238: Inventory recalculations, in time series, with respect to last year's report

Year	Total national emissions of greenhouse gases, not including carbon dioxide from LULUCF		
	Resubmission 2010	Submission 2011	Change
	[Gg CO ₂ equivalent]	[Gg CO ₂ equivalent]	[%]
1990	1,251,333.04	1,248,676.03	-0.21
1991	1,205,540.86	1,202,863.75	-0.22
1992	1,154,387.06	1,152,732.22	-0.14
1993	1,144,170.05	1,144,105.22	-0.01
1994	1,125,606.96	1,124,050.11	-0.14
1995	1,125,530.46	1,120,669.44	-0.43
1996	1,145,839.03	1,140,275.74	-0.49
1997	1,107,490.47	1,104,158.21	-0.30
1998	1,081,969.46	1,078,407.33	-0.33
1999	1,048,999.79	1,044,271.54	-0.45
2000	1,050,543.63	1,042,832.70	-0.73
2001	1,064,598.93	1,057,699.52	-0.65
2002	1,044,789.97	1,037,433.87	-0.70
2003	1,040,853.73	1,031,365.13	-0.91
2004	1,029,203.78	1,021,962.64	-0.70
2005	1,005,967.63	1,000,533.54	-0.54
2006	1,010,935.77	1,002,893.20	-0.80
2007	986,772.58	980,838.16	-0.60
2008	984,503.74	981,886.68	-0.27

Source: own calculations; does not include carbon dioxide from LULUCF

In the area of emissions reported only as memo items (for information purposes), emissions from international air and sea transports have been recalculated for all years. The reasons for this include the new calculation, described in detail in Chapter 3.2.10.1, of the emissions inventory for all air transports, and the first-time inclusion of emissions from co-combustion of lubricants in international sea transports (cf. Chapter 3.2.2.3).

The sharp decrease, reported for 2008, in CO₂ emissions from biomass, amounting to minus 2.4 %, is due to the use of updated activity data. In this area, the previously used provisional figures have been replaced with figures from the 2008 Energy Balance.

Corrections of the biodiesel quantities used in railway transports (1.A.3.c, 2008) and in inland-waterway shipping (1.A.3.d, as of 2007), play virtually no role in this regard, however.

Table 239: Recalculations of memo-item inventory data provided in addition to data from last year's report

	1990	2008
	Change in [%]	
Emissions from international transports	3.55%	0.38%
Air transports	5.35%	0.47%
Maritime transports	0.93%	0.16%
Multilateral missions	NE	NE
CO₂ emissions from biomass	-0.05%	-2.40%

Source: Own calculations

10.2.1.1 Impacts on 1990 emissions levels

Total emissions for 1990 decreased only slightly – by a total of 0.21 % – as a result of the methodological corrections.

The largest changes, in terms of quantity, occurred in the *energy* and *industrial processes* sectors. In those areas, CO₂ emissions from combustion of blast furnace gas in power stations and boilers were shifted from CRF 2 to CRF 1; this led to contrary absolute changes that offset each other nearly completely.

Considerable changes in the areas of *solvents* (-919 Gg) and *agriculture* (-3,454 Gg) have also had a reducing effect on the inventory as a whole.

By contrast, the considerable increase seen in CH₄ and N₂O emissions (+588 % with respect to the Resubmission 2010) has only a slight effect on the overall inventory.

Other significant changes that did not enter into the inventory occurred in the *LULUCF* sector. In that area, extensive methodological revision has resulted in an increase in the emissions reported for 1990, amounting to about 11.000 Gg or more than 54 %.

More detailed pertinent information, in addition to that provided in the following table, is available in CRF tables 8(a)s1 and 8(a)s2.

Table 240: Recalculation of source-category-specific total emissions, for all gases in 1990

	Resubmission 2010 [Gg]	Submission 2011 [Gg]	Change [Gg CO ₂ equi.]	Change [%]
Total national emissions (not including CO ₂ from LULUCF)	1,251,333	1,248,676	-2,657	-0.21%
1. Energy	992,418	1,019,041	26,623	2.68%
2. Industrial processes	120,101	94,532	-25,568	-21.29%
3. Solvent and other product use	5,396	4,477	-919	-17.04%
4. Agriculture	90,194	86,740	-3,454	-3.83%
5. Land-use changes and forestry	-20,165	-31,175	-11,010	-54.60%
CO ₂ (net emissions / storage)	-20,277	-31,949	-11,672	-57.56%
N ₂ O + CH ₄ (emissions)	113	774	662	588.13%
6. Waste	43,111	40,424	0	0.00%

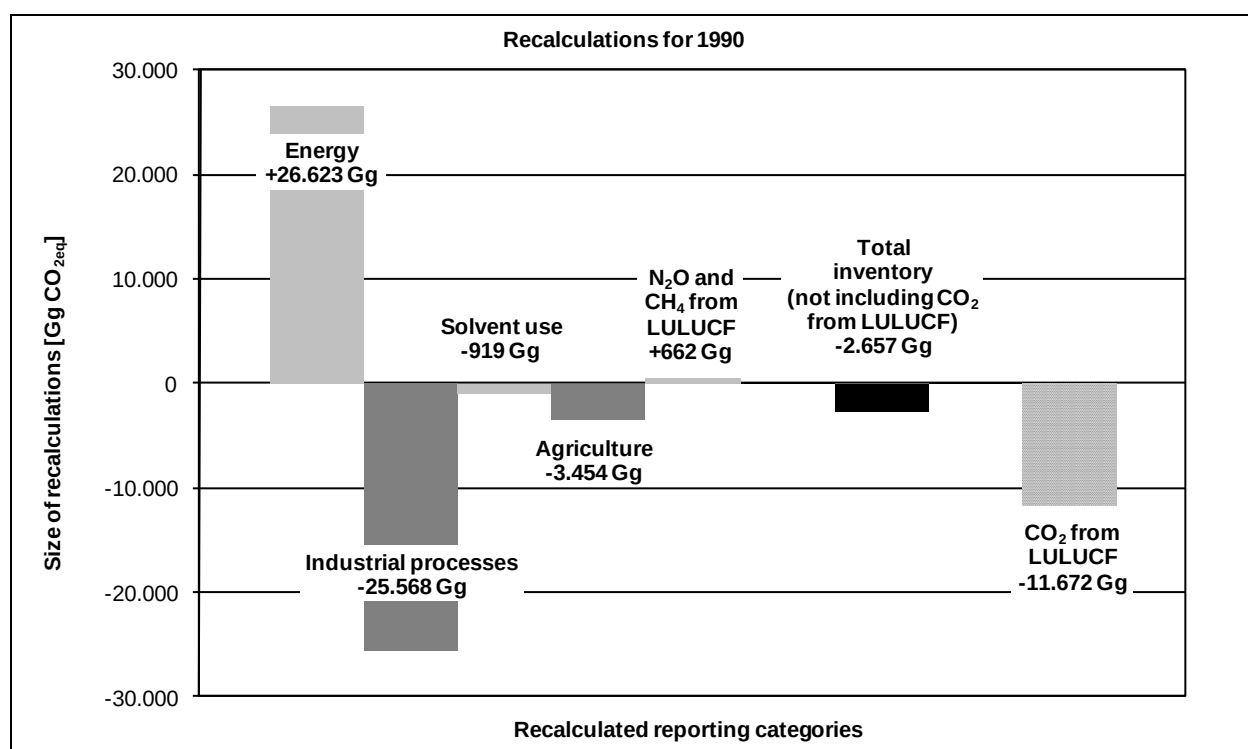


Figure 58: Recalculations of all greenhouse gases for 1990

10.2.1.2 Impacts on 2008 emissions levels

The total emissions from LULUCF (not including CO₂) reported for 2008 have decreased by only 0.27 % in comparison to the Resubmission 2010.

Here again, the largest changes, in terms of quantity, occurred in the sectors *energy* and *industrial processes* where, as described above, CO₂ emissions from combustion of blast furnace gas were shifted from CRF 2 to CRF 1. For 2008 as well, the contrary absolute changes offset each other nearly completely.

The changes in the areas of *solvents* (-1,504 Gg) and *agriculture* (-2,941 Gg) have also had a reducing effect on the inventory as a whole.

The changes in CH₄ and N₂O emissions in the *LULUCF* sector, at -15 Gg and -1.95 %, are considerably smaller than the corresponding figures described above for the year 1990.

Other significant changes that did not enter into the inventory also occurred in the *LULUCF* sector. In that sector, increasing CO₂ storage, and decreasing CO₂ emissions, led to a decrease of about 15,000 Gg, or more than 50 %, in the overall balance.

Additional information about recalculations is provided in CRF tables 8(a)s1, 8(a)s2 and 8(b) and in the table below.

Table 241: Recalculation of source-category-specific total emissions, for all gases in 2008

	Resubmission 2010 [Gg]	Submission 2011 [Gg]	Change [Gg CO ₂ equi.]	Change [%]
Total national emissions (not including CO ₂ from LULUCF)	984,504	981,885	-2,619	-0.27%
1. Energy	779,875	809,591	29,717	3.81%
2. Industrial processes	109,863	82,017	-27,846	-25.35%
3. Solvent and other product use	3,316	1,812	-1,504	-45.36%
4. Agriculture	77,449	74,508	-2,941	-3.80%
5. Land-use changes and forestry	30,185	15,216	-14,969	49.59%
CO ₂ (net emissions / storage)	29,396	14,443	-14,953	50.87%
N ₂ O + CH ₄ (emissions)	789	773	-15	-1.95%
6. Waste	13,211	13,182	-29	-0.22%

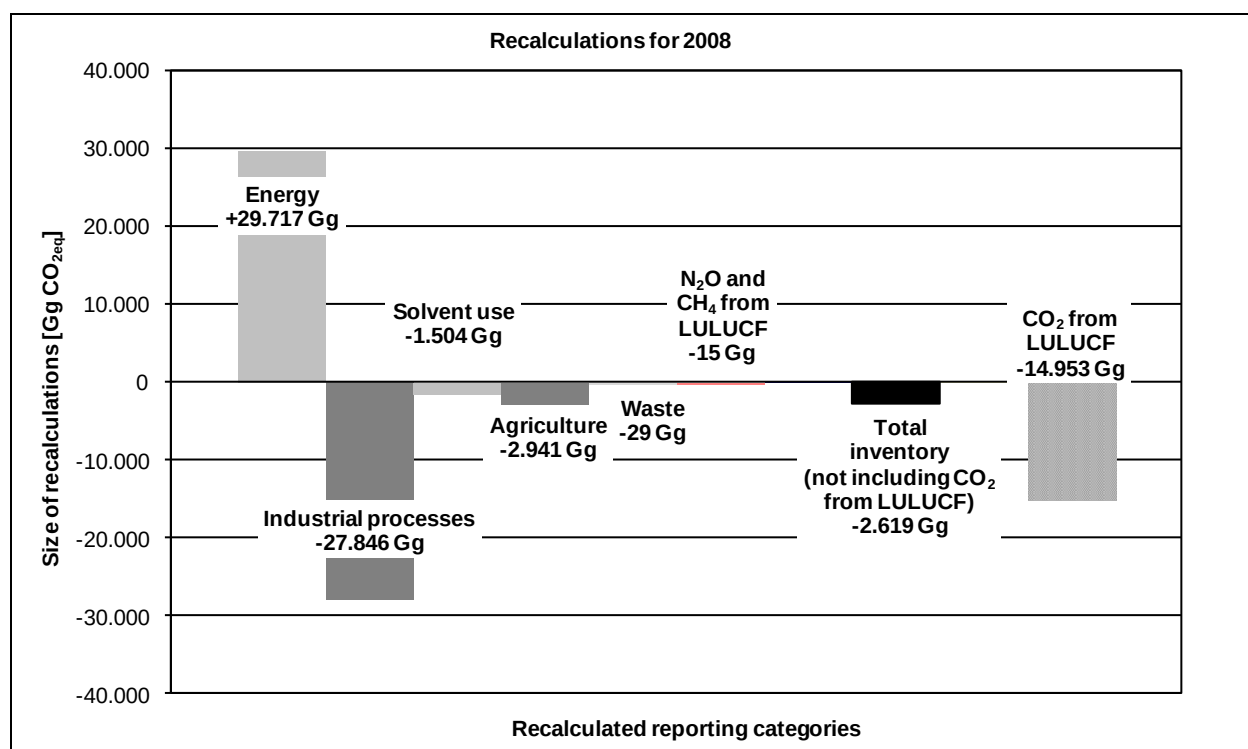


Figure 59: Recalculations of all greenhouse gases for 2008

10.2.2 KP LULUCF inventory

10.2.2.1 Impacts on 1990 emissions levels

Total sinks for 1990 increased only slightly – by a total of 9.94 % – as a result of corrections in methods (cf. Table 242). The increases are due primarily to changes in forest management, since carbon storage in managed forests is very large in relation to emissions from afforestation and deforestation.

Table 242: Recalculation of total KP-LULUCF emissions, for all gases in 1990

	2010 Submission [Gg CO ₂ eq]	2011 Submission [Gg CO ₂ eq]	Change [Gg CO ₂ eq]	Change [%]
Afforestation (KP3.3)	-49	934	983	2006.12%
Deforestation (KP3.3)	2,875	1,172	-1,703	-59.23%
Forest management (KP3.4)	-65,424	-70,927	-5,503	8.41%
Total	-62,599	-68,820	-6,221	9.94%

10.2.2.2 Impacts on 2008 emissions levels

The total storage for 2008 has increased by 217 % in comparison to the Submission 2010. That increase is due primarily to improved estimation of deforestation areas and of the pertinent emission factors.

Table 243: Recalculation of total KP-LULUCF emissions, for all gases in 2008

	2010 Submission [Gg CO ₂ eq]	2011 Submission [Gg CO ₂ eq]	Change [Gg CO ₂ eq]	Change [%]
Afforestation (KP3.3)	-2,615	-4,779	-2,164	82.75%
Deforestation (KP3.3)	16,394	1,066	-15,328	-93.50%
Forest management (KP3.4)	-20,331	-20,626	-295	1.45%
Total	-6,553	-24,339	-17,786	271.42%

10.3 Impacts on emissions trends and on time-series consistency

10.3.1 Greenhouse-gas inventory

The time-series consistency has improved as a result of the recalculations.

As a result, the trend for total national emissions (not including CO₂ from LULUCF) shows a reduction of 26.5 % with respect to the current base year.

As a result of the economic crisis, which had especially strong effects in 2009, CO₂ emissions (i.e. only CO₂) decreased markedly, by a full 7.0 %, with respect to 2008. CH₄ emissions also decreased considerably, by 4.8 %. Nitrous oxide emissions, on the other hand, decreased less significantly from their 2008 levels; the decrease amounted to only 0.7 %. The trends for HFC, PFC and SF₆ emissions have been diverging from each other: While 4.2 % more HFCs were emitted, with respect to 2008, the total reported quantities of PFCs dropped especially sharply, by more than 18 %. SF₆ emissions decreased 2 % with respect to the previous year.

10.3.2 KP LULUCF inventory

The time series are consistent, thanks to recalculations. In particular, use of a consistent method has made estimation of deforestation areas consistent, thereby significantly improving emissions estimates. For afforestation, deforestation and managed-forest areas, this has strongly increased storage (cf. Chapter 10.2.2).

10.4 Inventory improvements

10.4.1 Greenhouse-gas inventory

The following table summarises the improvements made in greenhouse-emissions reporting on the basis of the ERT's references and remarks in past reviews under the UN Framework Convention on Climate Change and the Kyoto Protocol. The table lists only aspects that were not already successfully addressed during the Review.

Table 244: Summary of the improvements documented in the NIR 2011

CRF		Recommendation / Aspect	Improvement	NIR Chapter
Complete-ness	ARR 2008 Art. 12 ARR 2009 Art. 9	ERT encourages Germany to provide , in its next submission, estimates for all categories reported as "NE"	With the 2011 submission category coverage were further improved. Misused notation keys were corrected.	Various
QA / QC	IRR 2007 Art. 39	ERT recommends to continue the implementation of the QA/QC plan, in particular (where feasible and appropriate) the establishment of regular and systematic external peer reviews including QA/QC activities undertaken by agencies outside the UBA	Germany conducted a peer review workshop on N2O emissions from product use, emissions from non-energy use and SF6 emissions from photovoltaic in 2009. For 2011 a further peer review workshop on agriculture and LULUCF is planned.	Chapter 1.6.2.2
Verification	IRR 2007 Art. 64	The ERT noted the Party's planned improvements in the estimation of emissions from non energy use of feedstock in the industrial processes sector. This is expected to lead to greater insight into how many fossil fuel industrial processes are included in the national energy balance under non-energy related consumption. The ERT recommends that Germany pursue such improvements.	Germany has been providing a comparison between the German energy balance and non energy use emissions of industrial processes since the submission 2010	Chapter 18.9
1.A.2	ARR 2009 Arts. 55, 56	ERT recommends that Germany avoid the discrepancies in the trend of production and emissions from combustion in iron and steel	Germany eliminated the discrepancies in the trend of this source category due to changes in the methodology.	Chapter 3.2.9.1
1.A.2.a	Saturday Letter 2010	ERT recommends that Germany use the activity data available from BGS statistics to estimate the consumption of blast furnace gas, estimate emissions from blast furnace gas using the fuel consumption and the CS EF for CO2 and N2O and report these in the relevant categories in line with the Revised 1996 IPCC GL and the IPCC GPG.	With the submission 2011 Germany uses the AD from the from the iron and steel statistics of the German Statistical Office.	Chapter 3.2.9.1
1.A.3.d	Saturday Letter 2010	The ERT recommends that Germany investigate the decrease in fuel use and recalculate emissions if appropriate.	Germany provided for the resubmission 2010 new consumption estimates based on extrapolation of freight transport volumes from 2007 onwards. The correction of the energy balance is pending.	Chapter 3.2.10.4; 10.1.1.4
1.A.4.c.iii	Saturday Letter 2010	ERT recommends that Germany estimate fuel consumption for deep sea fishing and estimate emissions of CO2, CH4, N2O by using the EF for international marine bunkers.	Germany provided for the resubmission 2010 a first set of consumption estimates based on fleet size and installed engine power.	Chapter 3.2.11; 10.1.1.4

CRF		Recommendation / Aspect	Improvement	NIR Chapter
2.A.1	IRR 2007 Art. 66	The ERT recommends that Germany continue monitoring average values of the CaO content of clinker so that an estimate can be developed periodically, for example every five years, to reflect changes in the industry, rather than rely on the same factor throughout the entire time series.	Germany conducted a research project on monitoring average values of the CaO content of clinker. The results were insert in the NIR 2011	Chapter 4.2.1
2.A.2	ARR 2008 Arts. 38, 41 Saturday Letter 2010	ERT requests Germany to recalculate the emissions of CO2 for the subcategory for years 1990 to 2008, including the production of omitted plants in the activity data. For transparency, Germany should provide data used for the estimation before and after the recalculation including: estimates for the production of lime in the additional plants, estimate of total production of lime and total consumption of limestone and dolomite before and after the recalculation, and EF used	Germany provides new estimates for source category 2.A.2 with the recalculation of 2010 emissions.	Chapter 4.2.2; 10.1.1.4
2.A.4	Saturday Letter 2010	Germany should calculate the emissions of CO2 for the subcategory 2.A.4 for years 1990 to 2008. The ERT recommends that Germany estimate these emissions using data for soda ash use in Germany based on data for production, exports and imports and subtracts from this amount the amount of soda ash already taken in account in other categories of the inventory. The emissions of soda ash use should be calculated by multiplying the amount of the remaining soda ash by the appropriate emission factor.	Germany provides new estimates for source category 2.A.4. Germany is providing the annual production of soda in Germany inclusive the annual imports and exclusive the annual exports. The resulting amount of soda ash is the annual activity data used for calculation of CO2-emissions from soda ash used. The resulting CO2-emissions are part of resubmission 2010.	Chapter 4.2.4; 10.1.1.4
2.B.1	Saturday Letter 2010	ERT requests Germany to recalculate the emissions of CO2 for the subcategory 2.B.1 for years 1990 to 2008 in line with the provisions of the Revised 1996 IPCC Guidelines, by eliminating the subtraction of the recovered CO2	Germany provides new estimates for source category 2.B.1. For the resubmission the sum of CO2-emissions and CO2 used for recovery are reported as CO2-emissions from ammonia production.	Chapter 4.3.1; 10.1.1.4
2.B.2	Saturday Letter 2010	ERT requests Germany to recalculate the emissions of N2O for the subcategory 2.B.2 for years 2001 to 2008.	Germany provides new estimates for source category 2.B.2. The mistake is corrected and the new and correct emissions are reported under 2B2.	Chapter 4.3.2; 10.1.1.4
4.A.	ARR 2009 Art. 76	ERT recommends that Germany revise the calculations for dairy cattle herds regarding average gross energy intake	The methodology of calculating the average gross energy intake of dairy cattle herds were revised in the submission 2011	Chapter 6.1.4.3
4.A.1	Saturday Letter 2010	ERT recommends that Germany use Methane Conversion Rate parameters developed under European conditions in line with the IPCC good practice guidance	Germany uses a MCF of 6 in the resubmission 2010 and hence also in the submission 2011	Chapter 6.2.2.3
4.B.	ARR 2009 Art. 77	ERT recommends that Germany improve the transparency of the NIR by providing detailed information on Efs, volatile solids excretion rate, CH4-producing potential and CH4 conversion factor (MCF) by animal subcategory and animal waste management system.	Germany provides a detailed description of EFs, volatile solids excretion rate, CH4 producing potential and MCF in the respective chapter of the NIR 2011	Chapter 6.3.2
4.B.	ARR 2009 Art. 85	ERT recommends that Germany correct the errors in calculating the amount of N reported in each of the	Germany corrects the errors in calculating the amount of N reported in each of the AWMS in the	Chapter 6.3.4

CRF		Recommendation / Aspect	Improvement	NIR Chapter
		AWMS for each animal type	Submission 2011	
4.B.1	Saturday Letter 2010	The ERT recommends that Germany develop an updated country-specific ash content or to use the IPCC default	Germany applies the IPCC default (8 %) instead of the value used in the 2010 submission (13.9 %) for its submission 2011	Chapter 6.3.2.3
4.D.	ARR 2008 Art. 54	ERT recommended that Germany ensure that the reporting of emissions from urea application does not lead to double counting of CO2 emissions from ammonia production. Germany is encouraged to provide further details.	In its submission 2011 does not report emissions from urea application as there was a double counting with CO2 emissions from ammonia production.	
4.D.2	ARR 2009 Art. 92	ERT recommends that Germany correct the amount of N reported in the CRF table 4.D and include buffalo and goats in its next annual submission	Germany included EF for all animal categories in the Submission 2011	Chapter 6.5.2.1.2
4.D.3.2	Saturday Letter 2010	The ERT recommends that Germany revise its estimate for EFg using the IPCC good practice guidance default factor, or alternatively develop a country specific (CS) EFg for the 2010 submission, taking into account regional climate, soil and other relevant conditions. Such a CS shall include uncertainty estimates and substantiating documentation.	Germany uses for its resubmission 2010 and the submission 2011 the EFg and EFr recommended by the IPCC Good Practice Guidance.	Chapter 6.5.1
4.D.4	ARR 2009 Art. 86	ERT strongly recommends that Germany exclude the sink of CH4 in the subcategory other agricultural soils for all years from 1990 to 2007 from the inventory as it is no anthropogenic sink and there is no guidance on this CH4 sink	Germany does not report a sink of CH4 in the subcategory other agricultural soils in the submission 2011	
5	ARR 2009 Arts. 18,45b	ERT requests that a key category analysis be included in accordance with the IPCC GPG for LULUCF	Germany provided with the submission 2011 a TIER 2 key source analysis including LULUCF	Chapter 1.5; 17.1
5	IRR 2007 Arts. 6,81 ARR 2008 Arts. 57, 58 ARR 2009 Art. 89, 92	ERT recommended that Germany provide all necessary documentation and information on land-use definitions, the classification systems used for LULUCF categories, the areas and land-use data sets for the inventory preparation, and the assumptions used in extrapolations and interpolations of AD.	Germany provided with the NIR 2011 a comprehensive documentation and LU definitions, LULUCF categories and AD.	Chapter 7.2. – 7.7; 19.5
5.A.2	ARR 2008 Art. 61 ARR 2009 Art. 91	ERT recommends that Germany report under this category each carbon stock change occurring in land converted to forest land, and to apply the relevant methodologies provided in the IPCC GPG for LULUCF.	Germany applies the methodologies provided in the IPCC GPG for LULUCF to report each carbon stock changes occurring in land converted to forest land	Chapter 7.2.4.4.4
5.B.	ARR 2008 Art. 62	ERT recommended that Germany report all relevant information on the applied methodology for estimating carbon stock changes in living biomass and mineral soils in the next submission and revise the applied methodologies if it is not able to address the issues raised.	Germany provide with the NIR 2011 all relevant information on the applied methodology to estimate carbon stock changes in living biomass and mineral soils	Chapter 7.3.4
5.E.	ARR 2009 Art. 93	ERT noted the Germany did not report emissions of CO2 from composting under the waste sector. Therefore the ERT recommends that losses of DOM be reported under the category settlements in the next annual submission	Germany reports with its submission 2011 emissions of CO2 from composting under the waste sector	Chapter 8.5.1

CRF		Recommendation / Aspect	Improvement	NIR Chapter
6.A.1	ARR 2008 Art. 68 ARR 2009 Art. 99 Saturday Letter 2010	ERT recommended that Germany replace the amount of CH ₄ recovery from estimated data with actual monitored data	Germany provides new estimates for source category 6.A.1 based on monitoring data from the official German energy and waste statistics with the resubmission to the submission 2010.	Chapter 8.2.1; 10.1.1.4
6.A.1	Saturday Letter 2010	ERT recommends that Germany submit revised emission estimates that incorporate the abovementioned biodegradable waste disposed in landfills for period 2006-2008.	Based on the assumption explained in the respective NIR chapter Germany provides estimates for the CH ₄ emissions from MBT residues for the years 2004 to 2008.	Chapter 8.2.1
6.A.1	ARR 2009 Art. 98	ERT recommends that Germany improve the transparency of reporting by providing detailed explanations for the derivation of country-specific EFs and justifying the applicability of the use of defaults from the IPCC 2006 GL in accordance with the IPCC GPG	Germany provides improved explanations in the respective chapter of the NIR 2011	Chapter 8.2.1

All measures are aimed at achieving complete consistency with the UNFCCC report guidelines and the IPCC Guidelines and at preventing any adjustments under the Kyoto Protocol.

Details relative to the planned improvements are provided in the relevant source-category chapters. The following table summarises the information provided in those chapters.

Table 245: Summary of the improvements planned in the source-category chapters

Category	Category name	Planned improvement	IP	STATUS	Source	Source reference	Reporting year
1.A	Combustion of fossil fuels	In future, CO ₂ verification is to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from emissions calculation (primarily, activity rates) are to be compared more closely with aggregated data from emissions trading.	2011	open	NIR	Chap. 3.2.1.2.3	2011
1.A.1.a	Public electricity and heat supply	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO ₂) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N ₂ O-emissions behaviour of combustion and gas-turbine systems and the CH ₄ -emissions behaviour of gas-turbine systems.	2011	open	NIR	Chap. 3.2.6.6	2011
1.A.1.a	Public electricity and heat supply	In addition, plans call for further improvement of the methods for calculating activity data for waste incineration.	2011	open	NIR	Chap. 3.2.6.6	2011
1.A.1.b	Petroleum refineries	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO ₂) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N ₂ O-emissions behaviour of combustion and gas-turbine systems and the CH ₄ -emissions behaviour of gas-turbine systems. The research project also covers power stations and bottom-heating systems in petroleum refineries.	2011	open	NIR	Chap. 3.2.7.6	2011
1.A.1.c	Production of solid fuels and other energy industries	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO ₂) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N ₂ O-emissions behaviour of combustion and gas-turbine systems and the CH ₄ -emissions behaviour of gas-turbine systems. The research project also covers power stations and other combustion systems of the mining sector.	2011	open	NIR	Chap. 3.2.8.6	2011
1.A.2.f	Other: Other own-electricity producers	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO ₂) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N ₂ O-emissions behaviour of combustion and gas-turbine systems and the CH ₄ -emissions behaviour of gas-turbine systems. The research project also covers power stations and other combustion systems of the manufacturing sector – other energy production.	2011	open	NIR	Chap. 3.2.9.11.6	2011
1.A.3.a	Civil aviation	The Federal Environment Agency continues to seek an agreement with Eurocontrol regarding the provision of original Eurocontrol data.	2011	open	NIR	Chap. 3.2.10.1.6	2011
1.A.3.a	Civil aviation	As soon as Eurocontrol provides data from the AEM 3 model, such data can be used in reporting. With such data, the applicable share for national air transports, the breakdown of kerosene consumption by the two relevant flight phases and NO _x , HC and CO emissions data would all be based on calculations pursuant to Tier 3b.	2011	open	NIR	Chap. 3.2.10.1.6	2011
1.A.3.d	Ship transports (maritime, inland shipping)	Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.3.d.	2011	open	NIR	Chap. 3.2.10.4.6	2011

Category	Category name	Planned improvement	IP	STATUS	Source	Source reference	Reporting year
1.A.3.e	Other transport	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO ₂) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N ₂ O-emissions behaviour of combustion and gas-turbine systems and the CH ₄ -emissions behaviour of gas-turbine systems. The research project also covers gas turbines in natural gas compressor stations.	2011	open	NIR	Chap. 3.2.10.5.6	2011
1.A.3.e	Other transport	In future, emissions from construction-sector transports will be reported under 1A.2.f ii. No additional improvements are planned at present.	2011	open	NIR	Chap. 3.2.10.5.6	2011
1.A.4	Solid fuels	The current survey of consumption and emissions of German high-seas fisheries, which is based on a number of highly simplified and conservative assumptions, is to be revised in the medium term.	2011	open	NIR	Chap. 3.2.11.6	2011
1.B.1.c	Solid fuels	Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at 300 million m ³ and assumed that some 5 million m ³ of these escape into the atmosphere. Since this figure is subject to large uncertainties, a research project on "Potential for release and use of pit gas" is working to improve it. Fugitive releases at ground surface amount to no more than 0.02 % of total gas releases.	2011	open	NIR	Chap. 3.3.1.3.6	2011
1.B.2	Oil and gas	The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.iii-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity rates for these categories.	2011	open	NIR	Chap. 3.3.2.2	2011
1.B.2.d	Oil and gas: Distribution / production	Even though the quantities involved are expected to be very small, plans call for quantification of gas releases from exploratory drilling in cases in which no blow-out preventers are used (in the near-surface range to depths of 400 m).	2011	open	NIR	Chap. 3.3.2.5.6	2011
1.C.1.B	Bunkering: International sea transports	A study is currently gathering AIS- based ship-movement data. The resulting bunkering-quantities data will then be used, in combination with also-updated specific emission factors, for description of the emissions to be assigned to Germany.	2011	open	NIR	Chap.3.2.2.3.6	2011
2.A.2	Lime production:	The emission factors determined, in the framework of a research project, on the basis of emissions declarations of German lime works (including works producing dolomite) are only of limited use for verification of the figures in the CSE. The completion of that project has been delayed.	2011	open	NIR	Chap. 4.2.2.6	2011
2.A.4	Production and use of soda / sodium carbonate	No specific improvements are planned at present. In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.	2011	open	NIR	Chap. 4.2.4.6	2011
2.A.5	Use of bitumen for roofing	The VDD plans to carry out additional considerations relative to export-import offsetting.	2011	open	NIR	Chap. 4.2.5.6	2011
2.A.6	Road paving with asphalt	Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.	2011	open	NIR	Chap. 4.2.6.6	2011
2.A.7 (a)	Mineral Products: Other – glass production	At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.	2011	open	NIR	Chap. 4.2.7.6	2011
2.C.1	Production of iron and steel	The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.	2011	open	NIR	Chap. 4.4.1.6	2011

Category	Category name	Planned improvement	IP	STATUS	Source	Source reference	Reporting year
2.C.3	Primary- aluminium production	Determination of uncertainties continues, with the involvement of the industry association. The correct PFC emissions for 2009 will be submitted later.	2011	open	NIR	Chap. 4.4.3.6	2011
2.C.4	Use of SF ₆ in aluminium and magnesium foundries	For some time now, discussions have been underway with users with the aim of determining how realistic it is to assume that the emission factor for the aluminium industry is "1". We expect such discussion to produce concrete results by the next round of reporting. In all likelihood, such results will lead to correction of the emission factor.	2012	open	NIR	Chap. 4.4.4.6	2011
2.D.1	Pulp and paper	The CO ₂ emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do not have to be reported. In future, CO ₂ of biogenic origin may also be reported, in the interest of enhancing transparency.	2011	open	NIR	Chap. 4.5.1.6	2011
4.A	Fermentation	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	2011	open	NIR	Chap. 6.2.6	2011
4.A (b)	Fermentation – cattle, swine, sheep, horses	Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH ₄ emissions from enteric fermentation.	2011	open	NIR	Chap. 6.2.6	2011
4.B	Manure management	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	2011	open	NIR	Chap. 6.3.2.6	2011
4.B	Fermentation – cattle, swine, sheep, horses	Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH ₄ emissions from enteric fermentation.	2011	open	NIR	Chap. 6.3.2.6	2011
4.B	Manure management	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	2011	open	NIR	Chap. 6.3.2.6	2011
4.B	Fermentation – cattle, swine, sheep, horses	With regard to planned improvements, the reader's attention is called to Chapter 6.3.2.6. The improvement in modelling of feeding of swine is expected to also influence the results for N ₂ O emissions from manure management.	2011	open	NIR	Chap. 6.3.4.6	2011
4.D	Agricultural soils	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	2011	open	NIR	Chap. 6.5.6	2011
4.D	Agricultural soils	In March 2011, the Federal Statistical Office plans to carry out a special survey of data relative to application of farm manure. The results of that survey will have an impact on the NH ₃ and NO emissions of relevance for indirect N ₂ O emissions.	2011	open	NIR	Chap. 6.5.6	2011
4.D	Agricultural soils	Currently, efforts to improve modelling of feeding of swine are underway. In addition, the Federal Statistical Office plans to conduct a survey of protein inputs in swine fattening. The model changes are also expected to affect the results for NH ₃ emissions from farm-manure management, which are of relevance with regard to indirect N ₂ O emissions from agricultural soils. In co-operation with the Federal Statistical Office, efforts are being made	2011	open	NIR	Chap. 6.5.6	2011

Category	Category name	Planned improvement	IP	STATUS	Source	Source reference	Reporting year
		to produce a reliable estimate of Germany's net imports of farm manure.					
4.D	Agricultural soils	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	2011	open	NIR	Chap. 6.5.6	2011
4; 5		Improvement of the QA/QC concept (cf. the answer to ERT: Action plan for resolving issues identified by the ERT regarding KP LULUCF).	2011	open	NIR	Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5. D	Wetlands	In the wetlands category, an effort is being made to derive country-specific emission factors for emissions of the greenhouse gases CO ₂ , N ₂ O and CH ₄ from peat extraction. To this end, measurements are being carried out, in the framework of the project "Organic Soils", that cover all phases of this form of land use (cf. Chapter 19.5.2.6). The results will be used for parametrisation and validation of mathematical models, and for determination of country-specific, regional default factors. As soon as they become available, the results of this project will enter into national reporting.	2011	open	NIR	Chap. 7.5.8	2011
5. E	Settlements	Planned source-specific improvements for this sector include determination of country-specific emission factors for vegetation cover in cities and settlements and along transport infrastructure. A preliminary study has been commissioned to this end. The project will determine carbon stocks, and their changes, in urban trees. (cf. Chapter 19.5.2.6).	2011	open	NIR	Chap. 7.6.8	2011
5.A	Forest land	Land-use changes In the new German Länder, the relevant areas and land-use changes were determined with the help of the data from the GSE FM-INT project. Forest-land parcels with an area of at least 0.5 hectares were categorised. That categorisation produced some discrepancies with forest areas as determined in accordance with the definition of "forest" used in the National Forest Inventory (BWI). A project is to be carried out with the aim determining whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005 (cf. also Chapter 19.5.1.1.3).	2011	open	NIR	Chap. 7.2.8.1	2011
5.A	Forest land	Land-use changes The National Forest Inventory 3 (Bundeswaldinventur 3; BWI 3), which is currently being prepared, will make it possible to determine relevant areas and land-use changes in a consistent manner for the entire territory of Germany. The results of BWI 3, which is being carried out from 2011 to 2012, will make it possible to estimate the areas and land-use changes for all LULUCF land categories for the period 2002 through 2012.	2011	open	NIR	Chap. 7.2.8.1	2011

Category	Category name	Planned improvement	IP	STATUS	Source	Source reference	Reporting year
5.A	Forest land	Litter and mineral soils Still-lacking L�nder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about half of the BZE II soil-survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving main soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition).	2011	open	NIR	Chap. 7.2.8.2	2011
5.A	Forest land	Furthermore, the B�K map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).	2011	open	NIR	Chap. 7.2.8.2	2011
5.A	Forest land	Litter and mineral soils In addition, improvements in estimating carbon-stock changes in organic soil cover are planned for future analyses. An approach that is stratified in accordance with tree plantations is planned.	2011	open	NIR	Chap. 7.2.8.2	2011
5.A	Forest land	Litter and mineral soils For Germany, the question arises as to how the carbon stocks in mineral soil and in litter will develop. Therefore, suitable models are to be developed that will make it possible to forecast the annual changes in carbon stocks, both at the regional level and for Germany as a whole.	2011	open	NIR	Chap. 7.2.8.2	2011
5.A	Forest land	Litter and mineral soils Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time for that inventory will be determined after evaluation of the BZE II survey has been completed.	2011	open	NIR	Chap. 7.2.8.2	2011
5.B; 5.C; 5.D	Cropland	The area-identification process, for all categories, will be converted to an approach that uses a point grid and that is consistent for purposes of reporting forest categories and reporting in the KP-LULUCF framework. In addition, that method will simplify use of other data/sources, such as data from the European LUCAS grid, and satellite/aerial photos, etc., thereby making it possible for backward projections to 1990 to draw on additional data sources.	2011	open	NIR	Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPI	2011
5.B; 5.C; 5.D	Cropland	The point raster will ensure that reporting for the "cropland" category is spatially and chronologically consistent. Additionally it will allow to display the land use changes between 1990 and 2000.	2011	open	NIR	Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPI	2011
5.B; 5.C; 5.D	Cropland	Changes in the system for reporting emissions from mineral soils: • Derivation of typical, use-dependent carbon stocks in mineral soils, weighted by soil type and area, for all of Germany • Development of a new system for describing carbon-stock changes as a function of land use	2011	open	NIR	Chap. 7.3.8, 7.4.8, 19.5.2.6; ActPI	2011
5.B; 5.C;	Cropland	New emission factors, differentiated by soil type and soil use, for organic soils	2011	open	NIR	Chap. 7.3.8,	2011

Category	Category name	Planned improvement	IP	STATUS	Source	Source reference	Reporting year
5.D						7.4.8, 19.5.2.6	
5.B; 5.C; 5.D	Cropland	Change in the system for determining carbon-stock changes in biomass: • Reduction in the total number of emission factors, via calculation of area-weighted mean values for all of Germany. • An increase, over the number used to date, in the number of plant species that enter into area-weighted mean values	2011	open	NIR	Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland	Change in the system for determining carbon-stock changes in biomass: • Calculation of carbon stocks separately for above-ground and below-ground biomass • New country-specific default factors for carbon stocks in wood plantations outside of forests	2011	open	NIR	Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland	Complete, GPG-conformal uncertainties calculation	2011	open	NIR	Chap. 7.3.8, 7.4.8, 19.5.2.6	2011
6.A.1	Controlled landfilling of waste	An experts' assessment (WASTECONSULT INTERNATIONAL, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model.	2011	open	NIR	Chap. 8.2.1.6	2011
6.A.1	Controlled landfilling of waste	In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.	2011	open	NIR	Chap. 8.2.1.6	2011
6.D.1	Composting	Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH ₄ and N ₂ O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. This project, when completed, is expected to yield new emission factors for both gases.	2011	open	NIR	Chap. 8.5.1.6	2011
6.D.2	MBT	The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date.	2011	open	NIR	Chap. 8.5.2.6	2011

10.4.2 KP & LULUCF

The improvements described in the Convention inventory for the LULUCF sector in areas 5.A and 5.B.2.1 through 5.F.2.1 are also to be applied to the KP-LULUCF inventory (cf. Chapter 10.4.1).

10.5 Recalculations as a result of the In-Country Review 2010

After the most recent review of the 2010 greenhouse-gas inventory, in the framework of an In-Country Review, recalculations were carried out for a number of areas of the inventory. While most of the changes resulting from the recalculations were small, some were large, so that ultimately a need for a Resubmission 2010 was seen.

The data provided in the Resubmission 2010 are the basis for all recalculations carried out in the present Submission 2011 and described both in the context of the source categories themselves and in Chapters 10.1 through 10.3. The following section presents a brief description of all recalculations carried out in the framework of the Resubmission 2010, along with a description of the relevant impacts on the 2010 greenhouse-gas inventory.

10.5.1 Recalculations carried out as a result of the In-Country Review 2010: impacts on the overall inventory for 2010

All in all, the recalculations described below that were made in the framework of the Resubmission 2010 led to the following changes in the overall 2010 greenhouse-gas inventory:

The total emissions for 1990 increased by 19,486 Gg CO₂ equivalents, or 1.58 %, over the corresponding figure reported in the 2010 inventory. The correction for 2008, at +25,654 Gg or +2.68 %, was even more pronounced. The largest increase, amounting to +28,437 Gg or nearly 3 %, occurred in the figures reported for 2007.

For all years in question, the majority of the absolute corrections were carried out in CRF 4: In that category, annual emissions levels increased by more than 10,000 Gg throughout. The main driver of the changes was a recalculation of emissions from agricultural soils (4.D). That recalculation accounted for nearly 90 % of the level increases made in CRF 4, throughout the entire time series.

Not-insignificant emissions increases also occurred in CRF 1, 2 and 6: Within CRF 1, those increases occurred primarily in the sector 1.A.2 – Manufacturing Industries and Construction. The relevant changes are relatively high, especially for the years as of 2004; they account for about one-third of the increases occurring overall. The level increases occurring in CRF 2 grow in magnitude continually from 1990 on (1990: +1,874 Gg; 2008: +4,970 Gg), reaching a maximum plus of 5,682 Gg in 2007, and they contribute to the correction of the overall 2010 inventory shown below.

In CRF 6, the level increases first increase continually, from +2,688 Gg in 1990 to a maximum of +6,090 Gg in 1996. Subsequently, they decrease continually, to a level of +2,352 Gg in 2008.

In contrast to the other main categories, CRF 3 – Solvents and CRF 5 – LULUCF remain unaffected by the recalculations carried out as a result of the In-Country Review 2010. The emissions figures reported in the Submission 2010 were used, without any changes, in the Resubmission 2010.

Minimal changes in reported emissions levels occurred within the memo items (for information purposes only), in which part of the emissions from international sea transports will in future be allocated to national sources, and in CO₂ emissions from biomass, which had to be changed as a result of corrections of biomass inputs in CRF 1.

All of the recalculations carried out as a result of remarks made by the Expert Review Team in the "Saturday Letter" are described in greater detail in Chapter 10.5.2, with regard to specific content, to the pertinent impacts on the relevant source-category inventories and to the pertinent impacts on the overall inventory.

Table 246: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 - 2008

Emission Source	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Categories	(Gg CO₂ equivalent)																			
Total National Emissions	19,468	19,468	19,753	19,699	20,145	20,509	24,091	23,616	23,005	21,826	21,497	25,766	23,104	23,500	26,226	28,466	27,585	26,839	28,437	25,654
1. Energy	2,757	2,757	3,592	3,504	2,870	2,961	5,015	3,880	3,820	2,420	2,748	6,307	3,730	3,313	5,758	7,901	7,101	7,465	9,400	7,087
A. Fuel Combustion	2,756	2,756	3,591	3,503	2,869	2,960	5,014	3,879	3,819	2,419	2,747	6,306	3,729	3,311	5,756	7,900	7,100	7,464	9,399	7,086
2 Manufacturing Industries and Construction	2,612	2,612	3,446	3,381	2,725	2,816	4,870	3,713	3,686	2,286	2,600	6,194	3,613	3,221	5,674	7,818	7,018	7,390	8,991	6,582
3 Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	334	430
4. Other Sectors	144	144	144	122	144	144	144	166	133	133	147	113	116	90	82	82	82	74	74	74
B. Fugitive Emissions from Fuels	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2. Oil and Natural Gas	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2. Industrial Processes	1,874	1,874	1,726	1,620	2,294	2,457	2,741	2,725	2,900	2,912	2,816	3,039	2,899	3,783	4,152	4,725	5,026	5,193	5,682	4,970
A Mineral Products	421	421	325	245	246	269	241	237	260	281	264	273	299	275	306	413	301	289	303	301
B Chemical Industry	1,453	1,453	1,401	1,375	2,048	2,188	2,500	2,488	2,640	2,631	2,552	2,766	2,600	3,508	3,846	4,312	4,725	4,903	5,379	4,669
3. Solvent and Other Product Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. Agriculture	12,149	12,149	11,201	10,858	10,865	10,198	10,748	10,921	10,909	10,971	11,229	11,358	11,140	10,797	10,562	11,073	10,943	10,695	10,584	11,246
A Enteric Fermentation	1,013	1,013	921	1,041	1,096	1,083	1,113	1,158	1,146	1,158	1,179	1,182	1,234	1,224	1,245	1,229	1,252	1,225	1,246	1,256
B Manure Management	170	170	156	153	152	182	182	183	178	173	175	170	172	168	167	164	164	158	159	164
D Agricultural Soils	10,966	10,966	10,124	9,664	9,617	8,932	9,453	9,580	9,586	9,639	9,875	10,007	9,735	9,405	9,150	9,680	9,527	9,312	9,179	9,826
5. Land Use, Land Use Change and Forestry (N₂O only)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Waste	2,688	2,688	3,234	3,717	4,116	4,893	5,586	6,090	5,376	5,523	4,704	5,061	5,334	5,607	5,754	4,767	4,515	3,486	2,772	2,352
6.A Solid Waste Disposal on Land	2,688	2,688	3,234	3,717	4,116	4,893	5,586	6,090	5,376	5,523	4,704	5,061	5,334	5,607	5,754	4,767	4,515	3,486	2,772	2,352
Memo Items:	-139	-139	-144	-122	-144	-144	-144	-166	-133	-133	-147	-113	-116	-90	-82	-82	-82	-74	-60	-54
International Bunkers	-139	-139	-144	-122	-144	-144	-144	-166	-133	-133	-147	-113	-116	-90	-82	-82	-82	-74	-74	-74
Marine	-139	-139	-144	-122	-144	-144	-144	-166	-133	-133	-147	-113	-116	-90	-82	-82	-82	-74	-74	-74
CO₂ Emissions from Biomass (8)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	20

Lines with no recalculations are greyed out.

Table 247: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on total emissions

Total emissions	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	Gg CO ₂ equivalent	1,231,865	1,185,787	1,134,688	1,124,025	1,105,098	1,101,440	1,122,223	1,084,485	1,060,143	1,027,503
Resubmission 2010		1,251,333	1,205,541	1,154,387	1,144,170	1,125,607	1,125,530	1,145,839	1,107,490	1,081,969	1,049,000
Absolute change		19,468	19,753	19,699	20,145	20,509	24,091	23,616	23,005	21,826	21,497
Relative change	%	1.58	1.67	1.74	1.79	1.86	2.19	2.10	2.12	2.06	2.09
Total emissions	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2010	Gg CO ₂ equivalent	1,024,777	1,041,495	1,021,290	1,014,628	1,000,738	978,383	984,097	958,335	958,850	
Resubmission 2010		1,050,544	1,064,599	1,044,790	1,040,854	1,029,204	1,005,968	1,010,936	986,773	984,504	
Absolute change		25,766	23,104	23,500	26,226	28,466	27,585	26,839	28,437	25,654	
Relative change	%	2.51	2.22	2.30	2.58	2.84	2.82	2.73	2.97	2.68	

Table 248: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on carbon-dioxide emissions

CO ₂ emissions	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	Gg CO ₂	1,016,438	978,446	929,323	919,174	904,006	903,407	926,278	894,733	888,729	861,727
Resubmission 2010		1,021,065	983,759	934,443	924,334	909,420	911,156	932,877	901,447	894,057	867,286
Absolute change		4,626	5,313	5,120	5,160	5,414	7,748	6,599	6,713	5,328	5,558
Relative change	%	0.46	0.54	0.55	0.56	0.60	0.86	0.71	0.75	0.60	0.65
CO ₂ emissions	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2010	Gg CO ₂	864,733	893,191	921,759	922,193	905,049	887,701	897,128	871,887	862,488	
Resubmission 2010		874,071	899,814	928,307	931,347	916,260	898,328	908,014	884,966	873,170	
Absolute change		9,338	6,623	6,548	9,154	11,211	10,627	10,886	13,079	10,682	
Relative change	%	1.08	0.74	0.71	0.99	1.24	1.20	1.21	1.50	1.24	

Table 249: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on methane emissions (absolute)

CH₄ emissions, absolute	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	Gg CH ₄	4,919	4,668	4,461	4,425	4,196	4,040	3,899	3,716	3,465	3,424
Resubmission 2010		5,103	4,873	4,695	4,680	4,489	4,368	4,253	4,035	3,791	3,713
Absolute change		184	205	234	255	293	328	354	319	326	289
Relative change	%	3.75	4.40	5.24	5.77	6.99	8.11	9.08	8.59	9.42	8.43
CH₄ emissions, absolute	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2010	Gg CH ₄	3,236	3,077	2,910	2,743	2,557	2,451	2,357	2,293	2,274	
Resubmission 2010		3,542	3,398	3,243	3,084	2,850	2,734	2,589	2,492	2,453	
Absolute change		305	321	333	341	293	282	232	199	180	
Relative change	%	9.44	10.43	11.45	12.44	11.47	11.52	9.84	8.68	7.90	

Table 250: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on methane emissions in CO₂ equivalents

CH₄ emissions, equivalent	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	Gg CO ₂ equivalent	103,299	98,019	93,685	92,924	88,116	84,839	81,885	78,035	72,761	71,906
Resubmission 2010		107,170	102,331	98,596	98,288	94,275	91,721	89,316	84,735	79,615	77,965
Absolute change		3,871	4,312	4,911	5,365	6,159	6,882	7,431	6,700	6,854	6,059
Relative change	%	3.75	4.40	5.24	5.77	6.99	8.11	9.08	8.59	9.42	8.43
CH₄ emissions, equivalent	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2010	Gg CO ₂ equivalent	67,959	64,623	61,102	57,604	53,687	51,474	49,498	48,146	47,745	
Resubmission 2010		74,372	71,362	68,102	64,770	59,847	57,405	54,367	52,323	51,518	
Absolute change		6,413	6,740	6,999	7,166	6,160	5,931	4,870	4,177	3,773	
Relative change	%	9.44	10.43	11.45	12.44	11.47	11.52	9.84	8.68	7.90	-

Table 251: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on nitrous oxide emissions (absolute)

N₂O emissions, absolute	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	Gg N ₂ O	258	249	251	244	245	244	250	241	198	186
Resubmission 2010		293	282	282	275	274	275	281	272	229	218
Absolute change		35	33	31	31	29	31	31	31	31	32
Relative change	%	13.71	13.12	12.42	12.74	11.76	12.49	12.35	12.86	15.73	17.14
N₂O emissions, absolute	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2010	Gg N ₂ O	186	192	188	186	193	186	183	190	194	
Resubmission 2010		218	224	220	218	229	222	219	226	230	
Absolute change		32	31	32	32	36	36	36	36	36	
Relative change	%	17.40	16.35	17.05	17.22	18.50	19.09	19.56	18.94	18.61	

Table 252: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 – 2008; here, on nitrous oxide emissions in CO₂ equivalents

N₂O emissions, equivalent	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	Gg CO ₂ equivalent	79,989	77,173	77,821	75,525	75,972	75,749	77,602	74,597	61,291	57,641
Resubmission 2010		90,959	87,301	87,490	85,146	84,909	85,209	87,188	84,189	70,935	67,521
Absolute change		10,970	10,128	9,668	9,621	8,936	9,460	9,586	9,592	9,644	9,880
Relative change	%	13.71	13.12	12.42	12.74	11.76	12.49	12.35	12.86	15.73	17.14
N₂O emissions, equivalent	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2010	Gg CO ₂ equivalent	57,572	59,593	58,376	57,532	59,960	57,775	56,654	59,028	60,166	
Resubmission 2010		67,587	69,334	68,329	67,438	71,055	68,802	67,738	70,208	71,366	
Absolute change		10,015	9,741	9,952	9,906	11,095	11,027	11,084	11,181	11,199	
Relative change	%	17.40	16.35	17.05	17.22	18.50	19.09	19.56	18.94	18.61	-

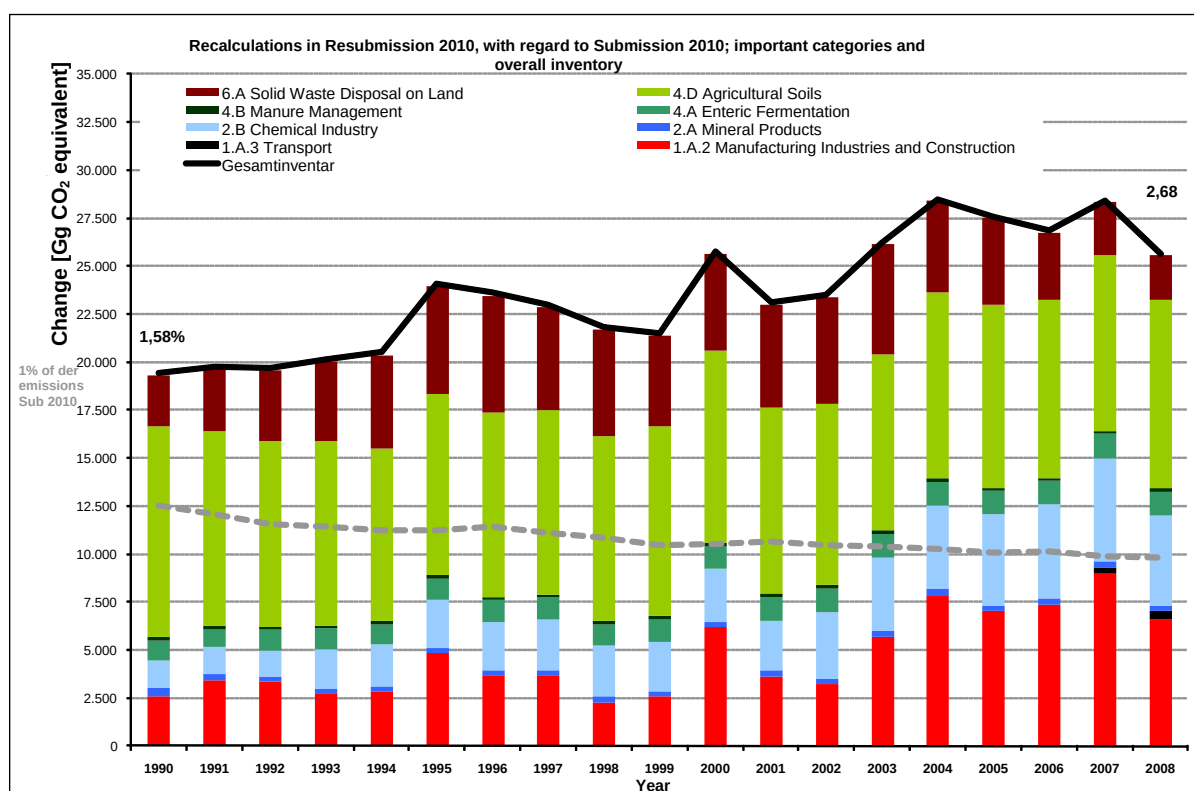


Figure 60: Impacts of recalculations carried out in the Resubmission 2010, with regard to the Submission 2010, on the overall inventory for the period 1990 - 2008

10.5.2 Findings of the ERT described in the Saturday Letter, and the resulting recalculations

10.5.2.1 Combustion of fuels – Other – Blast furnace gas (1.A.2.f)

In keeping with remarks made by the Expert Review Team, blast furnace gas losses and flaring are now included in 1.A.2.f Other.

Table 253: Impacts of inclusion of blast furnace gas losses and flaring on the greenhouse-gas emissions reported under 1.A.2.f Other, 1990-2008

	Units	1990	1995	2000	2005	2008
Submission 2010	[Gg CO ₂ -equiv.]	120,402.99	87,841.67	74,478.83	75,713.32	74,174.30
Resubmission 2010		123,014.77	92,711.90	80,672.36	82,731.05	80,756.45
Absolute difference		2,611.78	4,870.23	6,193.53	7,017.73	6,582.15
Relative difference	[%]	2.12	5.25	7.68	8.48	8.15

10.5.2.2 Venting and flaring (1.B.2.c)

As a result of remarks made by the Expert Review Team during the In-Country Review 2010, nitrous oxide emissions were recalculated with emission factors from the Good Practice Guidance 2000 (Table 2.16) for flaring in oil and gas production and in gas processing.

Table 254: Impacts of the described recalculations on the greenhouse-gas emissions reported under 1.B.2.c – Venting and flaring, 1990-2008

	Units	1990	1995	2000	2005	2008
Submission 2010	[t N ₂ O]	0.0	0.0	0.0	0.0	0.0
Resubmission 2010		3.56	3.30	3.48	3.74	3.16
Resubmission 2010	[t CO ₂ e]	1103.6	1023.0	1078.8	1159.4	979.6
Relative difference	[%]	100	100	100	100	100

10.5.2.3 Emissions from national coastal and inland shipping – here: emissions decrease as of 2007 (1.A.3.d)

With the Resubmission 2010, Germany upwardly corrected the activity data and emissions reported for this source category for the period as of 2007. The consumption figures provided by the relevant official statistics (official mineral-oil data and Energy Balances) are no longer correct, because a major refinery operator changed its reporting procedures as of 2007. Consequently, the consumption data are being extrapolated, for the time being, on the basis of transport distances travelled.

The impacts of the greenhouse-gas-emissions figures reported under 1.A.3.d, for years as of 2007, are shown in the following table.

Table 255: Impacts of correction of activity data for inland-waterway shipping on the emissions reported under 1.A.3.d, 1990-2008 (not including CO₂ aus Biodiesel)

	Units	1990	1995	2000	2005	2007	2008
Submission 2010	[Gg CO ₂ -equiv.]	2,060	1,752	882	954	508	404
Resubmission 2010		2,060	1,752	882	954	842	833
Absolute difference		0	0	0	0	334	430
Relative difference	[%]	0	0	0	0	66	106

10.5.2.4 Emissions from fisheries – here: emissions from German deep-sea fishing (1.A.4.c iii)

In its Resubmission 2010, Germany reported, for the first time, emissions of the German deep-sea fishing fleet. The relevant impacts on the total greenhouse-gas emissions reported under 1.A.4 are shown in the following table.

Table 256: Impacts of first-time inclusion of emissions of the German deep-sea fishing fleet on the emissions reported under 1.A.4, 1990-2008

	Units	1990	1995	2000	2005	2006	2007	2008
Submission 2010	[Gg CO ₂ -equiv.]	207,921	191,835	171,181	158,013	161,324	128,829	152,074
Resubmission 2010		208,065	191,979	171,294	158,095	161,398	128,903	152,147
Absolute difference		144	144	113	82	74	74	74
Relative difference	[%]	0.07	0.08	0.07	0.05	0.05	0.06	0.05

10.5.2.5 Emissions from industrial processes – Mineral products – lime production (2.A.2)

In the course of the inventory review, the Review Team determined that quantities produced by producers who are not members of the relevant national association had been overestimated. To ensure the completeness of the inventory data, a pertinent recalculation was presented during the review. Inclusion of plants that are not reflected in the total-production figures provided by the BV Kalk lime producers' association leads to slightly higher emissions as of 1990. For the source category as a whole, the relevant annual increases amount to 0.5 – 1 %. The trend has not changed. The details of the resulting changes are as follows:

Table 257: Recalculation of the CO₂ emissions of the German lime industry, in the course of the 2010 inventory review

	Units	1990	1995	2000	2005	2008
Submission 2010	[Gg CO ₂ -equiv.]	6,135	6,313	5,819	5,415	5,652
Resubmission 2010		6,176	6,355	5,862	5,453	5,701
Absolute difference		+41.4	+41.2	+42.8	+38.5	+49.1
Relative difference	[%]	+0.68	+0.65	+0.73	+0.71	+0.87

10.5.2.6 Emissions from industrial processes – Mineral products – soda ash production and use (2.A.4)

In the Resubmission 2010, the CO₂ emissions from use of soda ash were recalculated in keeping with a request of the Expert Review Team.

Table 258: Recalculation of CO₂ emissions from soda-ash use

	Units	1990	1995	2000	2005	2008
Submission 2010	[Gg CO ₂ -equiv.]	IE	IE	IE	IE	IE
Resubmission 2010		379.40	199.61	230.70	262.33	259.97
Absolute difference		379.40	199.61	230.70	262.33	259.97
Relative difference	[%]	100	100	100	100	100

Source: CSE database, for Resubmission 2010 and Submission 2011

10.5.2.7 Emissions from the chemical industry: Ammonia production (2.B.1)

In the Resubmission 2010, the CO₂ emissions from ammonia production were recalculated in keeping with a request of the Expert Review Team to the effect that CO₂ quantities from recovery must be included in CO₂ emissions from ammonia production.

Table 259: Recalculation of CO₂ emissions from ammonia production

	Value type	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	EM	Gg	4,292	3,756	3,803	3,648	3,615	4,505	4,503	4,416	4,580	4,436
Resubmission 2010	EM + Recovery	Gg	5,745	5,157	5,178	5,696	5,803	7,005	6,991	7,056	7,211	6,988
Difference	absolute figure	Gg	1,453	1,401	1,375	2,048	2,188	2,500	2,488	2,640	2,631	2,552
	Value type	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Submission 2010	EM	Gg	4,773	4,346	4,623	4,510	4,278	4,570	4,281	4,331	4,111	
Resubmission 2010	EM + Recovery	Gg	7,539	6,946	7,589	7,608	7,185	7,805	7,422	7,721	7,417	
Difference	absolute figure	Gg	2,766	2,600	2,966	3,098	2,907	3,235	3,141	3,390	3,306	

10.5.2.8 Emissions from the chemical industry: Nitric acid production (2.B.2)

In the 2010 reporting round, an error in aggregation of the EF(N₂O) distorted the emissions picture. The relevant correct source-specific recalculations are now shown in the CRF tables. In the Resubmission 2010, this error was corrected in keeping with a request of the Expert Review Team.

Table 260: Recalculation of N₂O emissions from 2.B.2 – Nitric acid production, 1990-2008

	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	[Gg CO ₂ -equiv.]	3,384	3,095	2,842	3,039	3,030	3,455	3,484	3,428	3,424	3,637
Resubmission 2010		3,384	3,095	2,842	3,039	3,030	3,455	3,484	3,428	3,424	3,637
Difference		0	0	0	0	0	0	0	0	0	0
	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Submission 2010	[Gg CO ₂ -equiv.]	3,814	3,593	3,470	3,509	3,420	3,428	3,367	3,179	2,839	
Resubmission 2010		3,814	3,593	4,012	4,257	4,824	4,918	5,129	5,168	4,202	
Difference		0	0	542	748	1,405	1,490	1,762	1,989	1,363	

10.5.2.9 4.A.1

During the In-Country Review in September 2010, the ERT objected to the fact that the German dairy-cow model calculates CH₄ emissions from enteric fermentation with the help of an approach, for the methane-conversion factor Y_m , that is based on North American circumstances and use of CH₄-reducing feed additives (Ellis et al., 2007). For 2008, use of that approach leads to $Y_m = 5.34\%$, while IPCC (2000) recommends 6% . The ERT maintained that in using the approach pursuant to Ellis et al. (2007), Germany underestimated CH₄ emissions from dairy-cow enteric fermentation in the Submission 2010. The ERT recommended that an approach pursuant to Mills et al. (2003) be used that would lead to $Y_m = 6.8\%$. Germany did not follow that recommendation, maintaining that the pertinent value would clearly overstate CH₄ emissions from dairy-cow enteric fermentation, a view that was upheld by a comparison with relevant results of neighbouring European countries. Instead, as of the Resubmission 2010 Germany uses $Y_m = 6\%$ pursuant to the IPCC (2000).

Table 261: Recalculation of CH₄ emissions from 4.A.1 – Enteric fermentation in dairy cows, 1990-2008

	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	[Gg CO ₂ -equiv.]	13,119	11,842	11,526	11,545	11,467	11,466	11,505	11,187	10,883	10,820
Resubmission 2010		14,132	12,763	12,566	12,641	12,551	12,579	12,663	12,333	12,041	11,999
Difference		1,013	921	1,041	1,096	1,083	1,113	1,158	1,146	1,158	1,179
	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Submission 2010	[Gg CO ₂ -equiv.]	10,483	10,579	10,336	10,295	10,116	10,093	9,762	9,809	10,080	
Resubmission 2010		11,665	11,813	11,560	11,540	11,345	11,345	10,988	11,055	11,336	
Difference		1,182	1,234	1,224	1,245	1,229	1,252	1,225	1,246	1,256	

10.5.2.10 4.B.1

In the dairy-cow section of the Submission 2010, Germany used a national ash-content figure in calculating excretions of volatile solids (VS). The value it used was 13.9% , while the IPCC (2000) recommends 8% . The ERT found that use of the higher national figure would result, indirectly, in underestimation of CH₄ emissions from manure management. Therefore, as of the Resubmission 2010 Germany uses the figure pursuant to the IPCC (2000).

Table 262: Recalculation of CH₄ emissions from 4.B.1 – Manure management for dairy cows, 1990-2008

	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	[Gg CO ₂ -equiv.]	2,484	2,283	2,228	2,224	2,660	2,660	2,673	2,595	2,529	2,557
Resubmission 2010		2,654	2,439	2,380	2,377	2,843	2,843	2,856	2,773	2,703	2,732
Difference		170	156	153	152	182	182	183	178	173	175
	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Submission 2010	[Gg CO ₂ -equiv.]	2,476	2,505	2,449	2,440	2,396	2,387	2,308	2,325	2,399	
Resubmission 2010		2,646	2,677	2,617	2,607	2,560	2,551	2,466	2,484	2,563	
Difference		170	172	168	167	164	164	158	159	164	

10.5.2.11 Indirect N₂O emissions from agricultural soils, as a result of leaching and surface runoff (4.D.3.2)

For the Submission 2010, Germany calculated indirect N₂O emissions from leaching and surface runoff with emission factor EF₅=0.0075 kg kg⁻¹ N₂O-N, in keeping with the 2006 Guidelines (IPCC, 2006). In the NIR 2010, and on the occasion of the In-Country Review in September 2010, Germany presented reasons why that emission factor is more suitable for Germany than the factor recommended in the 1996 Guidelines (EF₅=0.025 kg kg⁻¹ N₂O-N). The ERT found that those reasons were inadequate. As of the Resubmission 2010, therefore, Germany calculates indirect N₂O emissions from leaching and surface runoff using the higher emission factor pursuant to the 1996 Guidelines (IPCC, 1996).

Table 263: Recalculation of N₂O emissions from 4.D.3.2 – N₂O from leaching and surface runoff, 1990-2008

	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Submission 2010	[Gg CO ₂ -equiv.]	4,699	4,338	4,142	4,121	3,828	4,051	4,105	4,108	4,131	4,232
Resubmission 2010		15,666	14,462	13,806	13,738	12,760	13,504	13,685	13,694	13,771	14,107
Difference		10,966	10,124	9,664	9,617	8,933	9,453	9,580	9,586	9,640	9,875
	Units	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Submission 2010	[Gg CO ₂ -equiv.]	4,288	4,172	4,030	3,921	4,148	4,083	3,990	3,934	4,211	
Resubmission 2010		14,295	13,906	13,435	13,072	13,829	13,610	13,302	13,113	14,037	
Difference		10,007	9,735	9,405	9,150	9,680	9,527	9,312	9,179	9,826	

10.5.2.12 Managed disposal in landfills – landfilling of municipal waste (6.A.1)

In the 2010 review of the German greenhouse-gas inventory, in September 2010, the ERT objected to the following aspects of calculations for source category 6.A.1:

- Contributions to methane formation from mechanically and biologically treated waste (MBT waste), and from mineral waste with total carbon content of less than 5 %, were not covered by the inventory. In Germany, such waste with low methane-formation potential continues to be landfilled after the entry into force, in June 2005, of a prohibition on landfilling of biodegradable waste.
- The figures for rates of collection of landfill gas are not based on monitoring data; they are based on qualified estimates (which the ERT considers impermissible).

As a result of the review, the time series for the period 1990 to 2008 was completely recalculated. In the process, methane formation was calculated with inclusion of the small contributions from mineral waste and MBT waste landfilled after 2005 (cf. Chapter 8.2.1.2.1 and 8.2.1.2.2). The impacts on total methane formation are small, however. In the recalculation, monitoring data were used for determination of the rates of landfill-gas collection (cf. 8.2.1.2.8). Since those data do not include the total collected quantities of landfill gas, the recalculation leads to considerably higher methane emissions.

Table 264: Result of the recalculation (6.A.1)

	Units	1990	1995	2000	2005	2008
Resubmission 2010						
Methane produced	Gg CH ₄	2,169	2,095	1,611	1,202	943
	Gg CO ₂ eq	45,549	43,995	33,831	25,242	19,824
Methane collected	Gg CH ₄	126	176	352	447	421
	Gg CO ₂ eq	2,645	3,703	7,479	9,397	8,843
Methane emissions	Gg CH ₄	1,838	1,727	1,133	679	470
	Gg CO ₂ eq	38,607	36,267	23,786	14,263	9,868
Submission 2010						
Methane produced	Gg CH ₄	2,169	2,095	1,611	1,199	924
	Gg CO ₂ eq	45,549	43,995	33,831	25,179	19,404
Methane collected	Gg CH ₄	268	471	620	683	526
	Gg CO ₂ eq	5,628	9,891	13,020	14,343	11,046
Methane emissions	Gg CH ₄	1,710	1,461	892	464	358
	Gg CO ₂ eq	35,910	30,681	18,732	9,744	7,518
Absolute change (Resubmission 2010 : Submission 2010)						
Methane produced	Gg CH ₄	0	0	0	3	19
	Gg CO ₂ eq	0	0	0	63	399
Methane collected	Gg CH ₄	-142	-295	-268	-236	-105
	Gg CO ₂ eq	-2,982	-6,195	-5,628	-4,956	-2,205
Methane emissions	Gg CH ₄	128	266	241	215	112
	Gg CO ₂ eq	2,688	5,586	5,061	4,515	2,352
Relative change (Resubmission 2010 = 100 %)						
Methane produced	[%]	0.0	0.0	0.0	0.2	2.0
Methane collected		-112.7	-167.6	-76.1	-52.8	-24.9
Methane emissions		7.0	15.4	21.3	31.7	23.8

11 SUPPLEMENTARY INFORMATION AS REQUIRED PURSUANT TO ARTICLE 7 (1) OF THE KYOTO PROTOCOL

11.1 General information

11.1.1 The definition of "forest", and other criteria

The Federal Forest Inventory is the main data source used in determination of activity data and emission factors. Its definition of "forest", which serves as a basis for the report, is presented in Chapter 7.2.3.

Pursuant to UNFCCC (1998), areas are to be assigned to the classes *afforestation* and *deforestation* if they have been afforested / deforested since 1990. Such areas remain in those assigned classes until the end of the commitment period. As a result, such areas show continual growth. For afforested areas, so GPG LULUCF (IPCC 2003), a further distinction must be made between a) areas that have not been harvested, or deforested via natural disruptions (subject to Art. 3.3) and b) areas that have been harvested, or deforested via natural disruptions (subject to Art. 3.3 that would otherwise be subject to Art. 3.4). Germany has no areas, however, that have been afforested since 1990 and already harvested again. Pursuant to Art. 2 (2) No. 1 Federal Forest Act (BWaldG), short-cycle plantations do not fall within the national definition of "forests". Consequently, they are not included in greenhouse-gas reporting. Pursuant to Art. 2 (1) BWaldG, areas that have been afforested since 1990, but temporarily have no forest cover as a result of natural disasters, continue to be forest and must be reforested. For this reason, such areas must continue to be included in managed-forest areas pursuant to Art. 3.4. No deforestation as a result of natural disasters takes place in Germany.

For the new German Länder, maps of forest cover in 1990, and of relevant changes until 2002 and until 2005/2006, were developed in the project GSE Forest Monitoring. Inputs for relevant greenhouse-gas reporting (GSE 2003, GSE 2006, GSE 2007, GSE 2009) have been developed. The data, criteria and definitions used for that purpose are presented in Chapters 7.2.2.3, 7.2.3.2 and 19.5.1.1.

In keeping with the first German report under the Kyoto Protocol (UNFCCC 2007), the following definition of "forest", which accords with the relevant FAO definition, has been used:

- Area planted / covered by trees amounts to over 10 % of the relevant area
- The smallest area to be taken into consideration is 0.1 ha
- Potential tree height of at least 5 metres

Within the limits defined by the Marrakesh Accords, that definition is the one that comes closest to the definition used in the national forest inventory. As comparative studies have shown, the differences between different activity-data calculations carried out in accordance with the aforementioned definitions are negligible.

11.1.2 Selected activities under Article 3 (4) of the Kyoto Protocol

In keeping with its **first report** under the Kyoto Protocol, Germany has selected the option of crediting forestry activities pursuant to Article 3 (4) of the Kyoto Protocol.

11.1.3 Description of ways in which the definitions of all activities pursuant to Article 3.3, and of all selected activities pursuant to Article 3.4, have been implemented and applied in a constant manner over time

The definitions used by Germany for "new afforestation", "reafforestation" and "deforestation" are in accordance with GPG (IPCC 2003). Pursuant to the IPCC, "Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources (succession)⁷⁷." Reafforestation differs from new afforestation solely in terms of the time of the last forest cover, since those areas that, pursuant to the IPCC, must be considered newly afforested have not been forested since 31 December 1989.⁷⁸ Since the reporting period for Germany begins with base year 1990, and since inadequate data are available for differentiation of land-use forms prior to 1990, new afforestation and reafforestation are considered together in the present context. They are understood to refer to planting of trees on open, managed land, if the relevant rejuvenation suffices for producing forest in accordance with the national definition of "forest". In general, the time of new afforestation (or reafforestation) is the time at which the first activity in the relevant regeneration process was carried out. In the case of spontaneous regeneration of trees, the time of afforestation is the time at which the relevant national conditions for fulfillment of the definition of "forest" have been established. Accordingly, agricultural land can change from (cultivated) cropland into unmanaged pasture and, via spontaneous establishment of trees (succession), into forest. Pursuant to GPG (IPCC 2003), that sort of afforestation may be credited only if it is directly "human-induced". Good practice includes documenting the area conversions that are directly human-induced. Pursuant to the IPCC, the relevant proof to be provided includes proof that a decision in favour of afforestation or of permitting natural rejuvenation has been made.⁷⁹ Pursuant to German law, in Art. 10 (1) Federal Forest Act (BWaldG), every instance of initial afforestation of areas requires a "permit from the authority competent under Land (state) law". Pursuant to Para. 2, no permit is required only in those cases in which, for the area to be afforested, "afforestation has been mandated in a legally binding way, on the basis of other public legal provisions, or the requirements of regional planning and Land (state) planning are not affected". It may thus be assumed that all newly afforested areas fulfill the condition of "directly human-induced conversion", since the act of issuing a permit, the act of mandating in a legally binding manner and the preparation and establishments of regional and landscape plans all resuppose active decisions by humans.

The IPCC defines deforestation as "the direct human-induced conversion of forested land to non-forested land"⁸⁰. Harvesting of forested land that is subsequently rejuvenated does not count as deforestation, since such harvesting, pursuant to Art. 3.4, is part of forest management. This definition does not include "forest cover loss resulting from natural disturbances, such as wildfires, insect epidemics or wind storms", since "in most cases these areas will regenerate naturally or with human assistance"⁸¹. Such areas also fall within the

⁷⁷ Annex A No 1 lit. b FCCC/CP/2001/15/Add.1, page 58.

⁷⁸ IPCC LULUCF GPG (2003), Section 4.2.5.1.

⁷⁹ Cf. IPCC LULUCF GPG (2003), Section 4.2.5.2.

⁸⁰ Annex A No 1 lit. d FCCC/CP/2001/15/Add.1, page 58.

⁸¹ Cf. IPCC LULUCF GPG (2003), Section 4.2.6.1.

category of managed land pursuant to Art. 3.4 or, if the areas are afforested land, within the category of afforested land pursuant to Art. 3.3.

Where, since 1990, human activities have taken place on such areas temporarily without forest cover – activities such as road construction, settlement construction or other forms of land use (management of grassland or wetlands) – with the result that reforestation of the areas via land-use change is no longer possible, then so the IPCC, the areas must be considered deforested.

Forest management is the process, either formal or informal, of planning and integrating practices that support the fulfillment of the forest's relevant ecological, economic, social and cultural functions. The class "managed forest" comprises the forest that is managed. Managed forests include all forests that support the fulfillment of relevant ecological, economic, social and cultural functions. That category includes all forest areas that are accessible to society, regardless of whether the underlying land uses are visible or not (cf. also Chapter 19.5.1.4).

Since every land-use change toward forest is considered "new afforestation", every land-use change from forest to a different land-use category is considered "deforestation", and all forest areas that are not new forest are considered to be managed and subject to forest management (cf. the relevant explanation in the Annex Chapter 19.5.1.4), there is no possibility that the manner in which the relevant definitions are applied could change over time.

11.1.4 Description of the priority conditions and/or hierarchy among the activities pursuant to Article 3.4, and description of how those conditions/hierarchy have been constantly applied in determining land classification

Since broad definitions are used for forest management and for afforestation / deforestation, the activities pursuant to Arts. 3.3 and 3.4 (to the extent selected) are in keeping with the following categories pursuant to reporting under the UN Framework Convention on Climate Change:

Afforestation / reafforestation corresponds to the following:

- 5.A.2.1. Cropland to forest
- 5.A.2.2. Grassland to forest
- 5.A.2.3. Wetlands / water bodies to forest
- 5.A.2.4. Settlement to forest
- 5.A.2.5. Other to forest

Deforestation corresponds to the following:

- 5.B.2.1. Forest to cropland
- 5.C.2.1. Forest to grassland
- 5.D.2.1. Forest to wetlands / water bodies
- 5.E.2.1. Forest to settlement
- 5.F.2.1. Forest to other

Source and sink impacts of forest management correspond to the following:

- 5.A.1 Forest land remaining forest land

Methods for deriving activity data and emission factors are described in detail in Chapter 7.2.3. and 7.2.4.

11.2 Area-oriented information

11.2.1 Method used for determining area size pursuant to Article 3.3

The method used to derive activity data (areas) is described in Chapter 7.2.3. It corresponds to report method 1 pursuant to the GPG for LULUCF (IPCC 2003). The area reference unit is Germany. For the old German Länder, and for the period 1990 to 2009, the areas in the "forest" land-use form, and their additions and removals, are derived from the point data of the National Forest Inventories (BMELV 2005). For the new German Länder, area sizes, for the period 1990 to 2009, were determined using the data of the project "GSE FM-INT" (GSE 2003, GSE 2006, GSE 2007, GSE 2009).

11.2.2 Method used to develop the land-transition matrix

The method used to define forest areas, and to derive areas for the "change" classes in the old German Länder, is described in detail in Chapter 7.2.3.1. Chapter 7.2.3.2 describes the methods used to derive the areas for the new German Länder. Table 265 shows the land-use changes for forested land (deforestation), broken down by changes for the old German Länder and for the new German Länder, for the period 1990 to 2009. Conversion areas remain in their relevant conversion classes until the end of the commitment period for the 2012 Kyoto Protocol. As a result, the annual areas accumulate.

Table 265: Land-use changes from forested land (deforestation), broken down by old German Länder and new German Länder

Year	Deforestation [ha]		
	Old German Länder	New German Länder	Germany
1990	5,450	1,527	6,977
1991	10,900	3,053	13,954
1992	16,351	4,580	20,930
1993	21,801	6,106	27,907
1994	27,251	7,633	34,884
1995	32,701	9,159	41,861
1996	38,152	10,686	48,837
1997	43,602	12,212	55,814
1998	49,052	13,739	62,791
1999	54,502	15,265	69,768
2000	59,953	16,792	76,744
2001	65,403	18,318	83,721
2002	70,853	19,845	90,698
2003	76,303	21,371	97,675
2004	81,754	22,898	104,652
2005	87,204	24,424	111,628
2006	92,654	25,951	118,605
2007	98,104	27,478	125,582
2008	103,555	29,004	132,559
2009	109,005	30,531	139,535

11.2.3 Maps and/or databases for determining the geographic position of areas, and the relevant identification system

The following data sources were used in determination of activity data:

- National Forest Inventory 1 (Bundeswaldinventur; BWI 1)
- National Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventurstudie 2008 (IS08; Inventory Study)
- Datenspeicher Waldfonds (DSW)
- Bodenzustandserhebung im Wald I (BZE I; survey of soil condition in forests)
- Bodenzustandserhebung im Wald II (BZE II; survey of soil condition in forests)
- Soil-inventory data from the project BioSoil (BioSoil)
- GSE Forest Monitoring : Inputs for national greenhouse-gas reporting (GSE FM-INT)
- Amtliches Topographisch-Kartographisches Informationssystem (ATKIS®; Official topographic-cartographic information system)
- Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000 (BÜK 1000; overview soil map for the Federal Republic of Germany)
- Forest-fire statistics of the Federal Republic of Germany
- Fertiliser statistics of the Federal Statistical Office

Detailed descriptions of the data sources are presented in Chapter 7.2.2.

11.3 Activity-specific information

11.3.1 *Methods for determining carbon-stock changes, greenhouse-gas emissions and estimated reductions*

11.3.1.1 Description of methods and of the relevant applied and underlying assumptions

11.3.1.1.1 Biomass

Information on methods used for calculating carbon stocks, and carbon-stock changes, in above-ground and below-ground biomass is presented in the following chapters:

- Forest land remaining forest land cf. Chapter 7.2.4.1.1.
- New forest land cf. Chapter 7.2.4.1.2.
- Deforestation areas cf. also Chapter 19.5.1.3:

With regard to deforested areas, an individual-tree calculation was carried out on the basis of the BWI (NFI) 1, BWI 2 and IS08 inventories. For the period between the BWI 1 and BWI 2 inventories, only trees in the old German Länder were considered, since the BWI 1 inventory was carried out only there. The wood-stocks data for the old German Länder were applied to the new German Länder. For the period as of 2002, an individual-tree calculation, spanning the BWI 2 and IS08 inventories, was carried out for Germany as a whole. The carbon stocks were calculated for each LULUCF class and then, at the end of the process, combined within a deforestation class. The stocks of subsequent final-use classes were deducted – and thus taken into account. The carbon stocks released upon deforestation are counted, completely, as "emissions" in the same year.

Additional methodological descriptions are presented in the following chapters:

- Derivation of individual-tree biomass, cf. Chapter 7.2.4.1.3.
- Conversion into above-ground individual-tree biomass, cf. Chapter 7.2.4.1.4.
- Conversion into below-ground individual-tree biomass, cf. Chapter 7.2.4.1.5.
- Conversion of individual-tree biomass into carbon, cf. Chapter 7.2.4.1.6.
- Extrapolation algorithms for the status as of 1987, 2002 and 2008, cf. Chapter 7.2.4.1.7.
- Extrapolation algorithms for the change between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes using the "stock-change method"), cf. Chapter 7.2.4.1.8.
- Interpolation of time periods to obtain estimates of annual changes cf. Chapter 7.2.4.1.9.

11.3.1.1.2 Dead wood

Information on methods used for calculating carbon stocks and carbon-stock changes in dead wood is presented in the following chapters:

- Forest land remaining forest land cf. Chapter 7.2.4.2.1.
- New forest land cf. Chapter 7.2.4.2.2.
- Deforestation areas cf. also Chapter 19.5.1.3:

The C stocks in dead wood were calculated with data of the BWI 2 survey and the Inventurstudie 2008 (IS08). According to those calculations, the average carbon stocks

in dead wood amounted to 2.68 Mg ha⁻¹ in 2002 (BWI 2) and to 3.25 Mg ha⁻¹ in 2008 (IS08). For the years 2003 to 2007, the stocks were derived by interpolating the status data for the times 2002 and 2008. For the period 1990 to 2001, and for the period as of 2009, the stocks were derived via extrapolation of the same status data. In each case of deforestation, the carbon stocks in dead wood, for the relevant year, were taken into account immediately as C emissions.

11.3.1.1.3 Forest-floor litter and mineral soils

Information on methods used for calculating carbon stocks and carbon-stock changes in forest-floor litter is presented in the following chapters:

- Forest land remaining forest land cf. Chapter 7.2.4.3.1.
- New forest land cf. Chapter 7.2.4.3.2.
- Deforestation areas (cf. also Chapter 19.5.1.3):

For calculation of the litter ground cover, the status data of BZE I and the status data of BZE II / BioSoil soil inventories were used. According to the relevant calculations, the average carbon stocks in litter amounted to 20.1 Mg ha⁻¹ in 1990 (BZE I) and to 19.8 Mg ha⁻¹ in 2006 (BZE II / BioSoil). For the years 1991 to 2005, the stocks were derived by interpolating the status data for the times 1990 and 2006. For the period as of 2007, the stocks were obtained via extrapolation. In each case of deforestation, the carbon stocks in litter, for the relevant year, were taken into account immediately as C emissions.

Additional methodological descriptions are presented in the following chapters:

- Derivation of litter carbon stocks in 1990 (BZE I) and 2006 (BZE II/BioSoil), cf. Chapter 7.2.4.3.3.
- Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II/BioSoil), cf. Chapter 7.2.4.3.4.

11.3.1.1.4 Mineral soils

Information on methods used for calculating carbon stocks and carbon-stock changes in mineral soils is presented in the following chapters:

- Forest land remaining forest land (cf. Chapter 7.2.4.4.1)
- New forest land (cf. Chapter 7.2.4.4.2)
- Deforestation areas (cf. also Chapter 19.5.1.3):

The carbon-stock changes in mineral soils of deforested land were calculated by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTI-AK; cf. Chapter 7.3.4.1.).

Table 266: Emission factors for mineral soils of deforestation categories (negative = loss, positive = storage)

Land-use change	Emission factor [MgC ha ⁻¹ a ⁻¹]
Forest land converted to cropland	-21.21
Forest land converted to grassland	0
Forest land converted to wetlands	7.67
Forest land converted to settlements	0

Additional methodological descriptions are presented in the following chapters:

- Derivation of carbon stocks and carbon-stock changes, cf. Chapter 7.2.4.4.3.

- Results of derivation of carbon stocks and carbon-stock changes, cf. Chapter 7.2.4.4.4.

11.3.1.1.5 Organic soils

Information on methods used for calculating carbon stocks and carbon-stock changes in organic soils is presented in the following chapters:

- Forest land remaining forest land (cf. Chapter 7.2.4.5.1)
- New forest land (cf. Chapter 7.2.4.5.2)
- Deforestation areas (cf. also Chapter 19.5.1.3):
The carbon-stock changes in organic soils of deforested land were calculated by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTI-AK; cf. Chapter 7.3.4.2.).

Table 267: Emission factors for organic soils of deforestation categories (negative = loss, positive = storage)

Land-use change	Emission factor [MgC ha ⁻¹ a ⁻¹]
Forest land converted to cropland	-11
Forest land converted to grassland	-5
Forest land converted to wetlands	0
Forest land converted to settlements	-5

11.3.1.1.6 Other greenhouse-gas emissions from forests

Informationen relative to calculations of other greenhouse-gas emissions from forests is presented in the following chapters:

- Liming, cf. Chapter 7.2.4.6.1.
- Wildfire, cf. Chapter 7.2.4.6.2.
- Drainage, cf. Chapter 7.2.4.6.3.
- Land-use change from forest to cropland, cf. Chapter 7.2.4.6.4.

11.3.1.2 Justification for non-consideration of a given carbon pool or of greenhouse-gas emissions / reductions in connection with activities pursuant to Article 3.3 and selected activities pursuant to Article 3.4

For mineral soils of forest land remaining forest land, it was shown, from current data, that that pool is not a source for purposes of the greenhouse-gas inventories. A detailed pertinent description is presented in Chapter 7.2.4.4. Since the pertinent data are still incomplete, they have not been included in the CRF tables in which NO (not occurring) has been entered.

No dead wood occurs on new forest land. Since the dead wood pool thus cannot be a source, NO (not occurring) is entered in the CRF tables. A detailed description for this approach is presented in Chapter 7.2.4.2.2.

No fertilisation of forest areas, with mineral fertilisers, takes place in Germany. For this reason, fertilisation with mineral fertilisers is listed as NO (not occurring) in the CRF tables.

No areas with mineral soils that are subject to drainage are known; for this reason, NO (not occurring) is entered for this category in the CRF tables (cf. Chapter 7.2.4.6.3).

11.3.1.3 Information as to whether indirect or natural greenhouse gases and reductions were excluded

No indirect or natural greenhouse-gas emissions or sinks were taken into account – and thus excluded from the inventory.

11.3.1.4 Changes in data and methods since the last submission (recalculations)

In the report, new data sources and methods were taken into account, and recalculations were carried out for selected time series. Details on the new data sources used, and on the pertinent new calculations, are presented in Chapter 7.2.7.1, for forest land remaining forest land, and in Chapter 7.2.7.2, for new forest land.

In the Submission 2010, average biomass stocks for plantations were used in connection with deforestation. The National Forest Inventory sample data included individual-tree data for deforested land, however, that made it possible to estimate stock losses in connection with deforestation precisely. This year, such estimation via individual-tree data was carried out anew for the entire period from 1990 to 2009 (cf. Table 268).

Table 268: New calculation of C emissions from biomass of deforested land

Year	Biomass, Submission 2010 [GgC]	Biomass, Submission 2011 [GgC]	Difference [GgC]
1990	-566.07	-141.59	424.48
1991	-578.42	-141.59	436.83
1992	-590.77	-141.59	449.18
1993	-603.12	-141.59	461.53
1994	-615.47	-141.59	473.88
1995	-627.82	-141.59	486.23
1996	-640.17	-141.59	498.58
1997	-652.52	-141.59	510.93
1998	-664.87	-141.59	523.28
1999	-677.22	-141.59	535.63
2000	-689.57	-141.59	547.98
2001	-701.92	-141.59	560.33
2002	-708.40	-126.07	582.33
2003	-711.81	-126.07	585.74
2004	-715.21	-126.07	589.14
2005	-718.62	-126.07	592.55
2006	-722.02	-118.61	603.41
2007	-725.43	-127.92	597.51
2008	-3,355.92	-130.42	3,225.50
2009		-127.32	

Recalculation was also required for the pool "litter of deforested land", because pertinent new data became available and the relevant methods were expanded (cf. Chapter 7.2.4.3 and Chapter 11.3.1.1.3). Table 269 compares the results for the Submission 2011 with the corresponding values for the Submission 2010.

Table 269: New calculation of C emissions from litter of deforested land

Year	Litter, Submission 2010 [GgC]	Litter, Submission 2011 [GgC]	Difference [GgC]
1990	-202.20	-161.16	41.04
1991	-202.20	-159.72	42.48
1992	-202.20	-158.29	43.91
1993	-202.20	-156.85	45.35
1994	-202.20	-155.41	46.79
1995	-202.20	-153.97	48.23
1996	-202.20	-152.53	49.67
1997	-202.20	-151.09	51.11
1998	-202.20	-149.65	52.55
1999	-202.20	-148.21	53.99
2000	-202.20	-146.77	55.43
2001	-202.20	-145.33	56.87
2002	-202.20	-143.90	58.30
2003	-202.20	-142.46	59.74
2004	-202.20	-141.02	61.18
2005	-202.20	-139.58	62.62
2006	-202.20	-138.14	64.06
2007	-202.20	-136.70	65.50
2008	-931.05	-135.26	795.79
2009		-133.82	

11.3.1.5 Estimation of uncertainties

The following error calculations were carried out:

- Uncertainties in estimation of areas with land-use changes (cf. Chapter 7.2.5.1)
- Uncertainties in estimation of above-ground and below-ground biomass, cf. Chapter 7.2.5.2.
- Uncertainties in estimation pertaining to forest-floor litter and mineral soils, cf. Chapter 7.2.5.3.

11.3.1.6 Information about other methods

11.3.1.6.1 Comparison with results of other countries

A comparison of carbon-stock changes in living above-ground biomass (Table 270), as a result of afforestation, shows that Germany, and Poland, Belgium and the UK, rank high in terms of storage levels. The highest value, by a considerable margin, and thus the largest carbon-storage level, is seen in Switzerland. Germany, along with Poland, Belgium and France, also ranks high in the category of below-ground biomass. The largest storage level in below-ground biomass is found in the Netherlands. In the deforestation category, Germany is among the countries with the lowest carbon-stock losses. In the above-ground biomass category, only Austria has a lower loss level. The largest carbon losses are seen in Poland. In the managed forest category, Germany's carbon stocks are among the lowest. In the category of living above-ground biomass, only Switzerland has a smaller storage level. The only country with carbon-stock losses in both above-ground and below-ground biomass is Denmark. The largest storage levels are seen in Poland.

In the litter category (Table 271), Germany has the highest value for afforestation – and, thus, the largest C storage. France has a similarly high level. Germany has the second-highest carbon-stock losses, after the Netherlands, in the deforestation category. The lowest losses from deforestation are seen in Belgium.

Germany, along with the Netherlands, has the second-highest carbon-stock losses from dead wood (Table 272) in connection with deforestation. The largest relevant losses are found in Switzerland, while the highest are found in Belgium. Germany's carbon stocks in dead wood, as a result of forest management, are about as large as those of Denmark. Even higher storage is found in Switzerland. And France has even experienced carbon-stock losses as a result of forest management.

After the UK and France, Germany has the lowest storage in mineral soils (Table 273), as a result of afforestation. The largest C stocks are found in Austria and Belgium. The carbon-stock losses from mineral soils, as a result of deforestation, are lowest in Germany. Similarly low losses are seen in the Czech Republic. The largest losses are seen in Switzerland, the UK and Austria. The relevant table is not included here, as a result of a lack of comparative data, from neighbouring countries, relative to organic soils.

Table 270: Carbon-stock changes in living biomass (Germany, for 2009; other countries, for 2008)

Country ⁸²	Afforestation/ Reforestation [Mg C/ha]		Deforestation [Mg C/ha]		Forest Management [Mg C/ha]	
	above-ground	below-ground	above-ground	below-ground	above-ground	below-ground
AUT	1.00	0.18	-0.77	-0.20	NA	NA
BEL	2.66	0.53	-1.29	-0.26	NA	NA
CHE	4.05	IE	-5.44	IE	0.01	IE
CZE	1.52	0.30	-2.68	-0.54	0.54	0.11
DNK	0.22	0.04	-1.04	-0.17	-0.21	-0.03
FRA	1.10	0.47	-2.35	-0.54	1.26	0.40
GBR	2.46	IE	-3.40	IE,NO	1.27	IE
GER	2.62	0.51	-0.79	-0.12	0.34	0.10
NLD	2.14	0.93	-3.16	-0.60	NA	NA
POL	2.89	0.58	-56.35	-11.27	3.61	0.72

Source: UNFCCC 2010

⁸² AUT = Austria, BEL = Belgium, CHE = Switzerland, CZE = Czech Republic, DNK = Denmark, FRA = France, GBR = UK, GER = Germany, NLD = the Netherlands, POL = Poland

Table 271: Carbon-stock changes in litter (Germany, for 2009; other countries, for 2008)

Country ⁸²	Afforestation/ Reforestation [Mg C/ha]	Deforestation [Mg C/ha]	Forest Management [Mg C/ha]
AUT	IE	IE	NA
BEL	0.00	0.00	NA
CHE	NO	-0.66	NO
CZE	IE	IE,NA	NE
DNK	0.23	-0.21	NA
FRA	0.45	-0.18	0.00
GBR	0.10	IE,NO	0.31
GER	0.50	-0.96	0.00⁸³
NLD	NE	-1.70	NA
POL	IE	IE	IE

Source: UNFCCC 2010

Table 272: Carbon-stock changes in dead wood (Germany, for 2009; other countries, for 2008)

Country ⁸²	Afforestation/ Reforestation [Mg C/ha]	Deforestation [Mg C/ha]	Forest Management [Mg C/ha]
AUT	NO	IE	NA
BEL	NO	0.00	NA
CHE	NO	-0.34	0.18
CZE	NO	-0.07	NO
DNK	0.01	-0.02	0.10
FRA	0.00	-0.05	-0.10
GBR	IE	IE,NO	IE
GER	NO	-0.17	0.09
NLD	NE	-0.17	NA
POL	NA	IE	IE

Source: UNFCCC 2010

Table 273: Carbon-stock changes in mineral soils (Germany, for 2009; other countries, for 2008)

Country ⁸²	Afforestation/ Reforestation [Mg C/ha]	Deforestation [Mg C/ha]	Forest Management [Mg C/ha]
AUT	2.10	-2.41	NA
BEL	1.29	-1.32	NA
CHE	0.13	-3.68	NO
CZE	0.16	-0.07	NE
DNK	NR	NA,NR	NR
FRA	0.03	-0.71	0.01
GBR	0.01	-2.84	0.57
GER	0.07	-0.03	NO
NLD	NE	NE	NA
POL	NA	NA	NA

Source: UNFCCC 2010

11.3.1.7 The initial year of an activity, if after 2008

No relevant activities began after 2008.

⁸³ No areas to consider

11.4 Article 3.3

11.4.1 Information proving that activities pursuant to Article 3.3 began on or after 1 January 1990, and prior to 31 December 2012, and are directly human-induced

As described in Chapters 7.2.3.1 and 7.2.3.2, the process for determining land-use changes to and from forest covers land-use changes only as of 1990 for the new German Länder and only as of 1987 for the old German Länder (although, as a result of the method used, only the changes as of 1990 have entered into the present inventory). Since the available information covers only the period until the present, the relevant activities cannot have taken place between now and 2012.

With application of a broad definition of management and human impacts, it is assumed that the existence and implementation of a plan for landscape development must already be considered a direct impact. Germany is a densely populated and intensively managed country, and virtually all of its territory is covered by plans for landscape management (such as landscape plans) and for protection and management (for forests, for example, forest-management plans). Compliance with such plans is closely monitored by federal, Länder and municipal authorities. It may safely be assumed that every instance of land-use change, either from or to forest, is caused by human activity. Additional information is presented in Chapter 19.5.1.4.1.

11.4.2 Information about the distinction between a) harvest or forest disturbance that is followed by new forest formation and b) deforestation

In the German forestry sector (all forest areas are managed), it is common practice to manage larger-area uses as follows (to the extent such uses take place; in Germany, clear-cutting is prohibited by law): on such areas, planned rejuvenation is quickly carried out via either allowance of natural rejuvenation (efficient use of natural regeneration of forests) or artificial rejuvenation (planting). It is also possible to combine the two procedures. A similar approach is taken in connection with disruptions (especially wind-caused breakage and uprooting). In the case of large disturbances, rejuvenation/restoration measures are often supported by the state. Inclusion of managed forest in the definition applied (complete forest area, cf. Chapter 19.5.1.4.2) makes it possible for the system to include areas that are temporarily not forested.

11.4.3 Information about the size and geographic position of forest lands that have lost their forest cover but are not considered deforested

In the course of forest management, very small unforested areas (bare areas; accounting for <1% of total forest area) can occur. In keeping with the definition of "forest", such areas are considered to be forest, and they are covered by the sampling procedures used in forest inventories. For this reason, they enter into calculations relative to stocks and their changes.

11.5 Article 3.4

11.5.1 Information proving that activities pursuant to Article 3.4 began after 1 January 1990 and are human-caused

Since an integrated procedure is used for surveying forest lands, land-use changes and the stock changes caused by relevant activities, the statements made in Chapter 11.4.1 apply mutatis mutandis for the activity "forest management".

11.5.2 Information relative to management of cultivated areas and pastures, and to grassland restoration, if selected, for the base year

Germany has opted only for crediting of forest management pursuant to Article 3.4 KP (cf. Chapter 11.1.2).

No information about other activities is available.

11.5.3 Information on forest management

Germany's laws require that forests be properly and sustainably managed. Such actions must take account of forests' functions as sources of raw materials, as bases for species, soil, climate and water-body protection and as resources for public recreation and enjoyment. Forest management thus entails ongoing balancing of economic, ecological and social interests, with the aim of protecting forests' different functions in the long term. Additional information is presented in Chapter 19.5.1.4.2.

11.6 Further information

11.6.1 Key-source analysis for activities pursuant to Article 3.3, and for selected activities pursuant to Article 3.4

In connection with analysis for the UNFCCC inventory, key-source analysis was also carried out for activities pursuant to Article 3.3 and for selected activities pursuant to 3.4. The results are presented in tabular form in Chapter 1.5.2 of this report. The procedures, bases and methods used are described in detail in Chapter 17.1.3.

11.7 Informationen zu Artikel 6 (JI- & CDM-Projekte / Management der ERU)

In Deutschland können gemäß Paragraph 5, Absatz 1, Satz 1 des Projekt-Mechanismen-Gesetzes (ProMechG) keine Projekte im Bereich LULUCF genehmigt werden, die in Deutschland stattfinden sollen.

12 INFORMATION RELATIVE TO ACCOUNTING FOR KYOTO UNITS

12.1 Background information

According to the legal requirement the Standard Electronic Format (SEF) can be found in the Annex 6 (chapter 22.2.2) to this submission. The SEF has been generated with the SEF application version 1.2, provided by the secretariat at 9th of January 2009. The German registry were tested for the generation of the SEF by the UNFCCC. The secretariat awarded a SEF test certificate of conformity to the German registry, dated 2nd January 2009.

In addition a list of all issuance transactions of CER from the CDM registry into the national German registry is included in the Annex 6 (chapter 22.2.4.1).

12.2 Summary of information reported in the SEF tables

The year 2009 showed a much higher level of transactions as the starting year of the commitment period. Transactions with most European countries within the European Emissions Trading Scheme took place. In addition, Kyoto units have been transferred to non-European countries as well. In 2009 Germany converted ERUs for the first time. Two JI projects (track 1) have produced CO₂ offsets and the corresponding amount of 143,492 AAUs were converted into ERUs. Another figure is remarkable. Nearly 200,000 CERs were voluntary cancelled for compensation. The German Federal Government cancelled more than 96,000 CERs for compensation of official trips. The other part of the voluntary cancelled CERs came from companies, private individuals and NGOs.

12.3 Discrepancies and Notifications

12.3.1 *Discrepant transactions*

12.3.1.1 12.3.1.1 15/CMP.1 Annex I.E paragraph 12

The German registry had 130 discrepant transactions in 2009, without double counting when a transaction results in several error codes. 130 transactions had error code 4003 and 126 had error code 4010. Error code 4010 always appeared together with error code 4003.

12.3.2 *Reversal of storage information*

12.3.2.1 15/CMP.1 Annex I.E paragraph 13

Germany did not receive a reversal of storage notification in the reported year. No CDM notification occurred in 2009.

Germany has not received a notification for the replacement of ICER in accordance with paragraph 49 of the annex to decision 5/CMP.1.

12.3.3 *Non-certification notifications*

12.3.3.1 15/CMP.1 Annex I.E paragraph 14

Germany did not receive a non-certification notification. No CDM notification occurred in 2009.

Germany did not receive a notification for the replacement of ICER in accordance with paragraph 50 of the annex to decision 5/CMP.1.

12.3.4 Non-replacement notifications

12.3.4.1 15/CMP.1 Annex I.E paragraph 15

No non-replacement took place in 2009. Germany did not neglect any replacement according to paragraph 56 of the annex to 5/CMP.1.

12.4 Publicly accessible information

12.4.1 15/CMP.1 Annex II.E Paragraph 32.(g)

The publicly available information is also based on the requirements of Annex VXi of the Commission Regulation (EC) No 994/2008 of 8 October 2008 for a standardised and secured system of registries pursuant to Directive 2003/87/EC of the European Parliament and of the Council and Decision No 280/2004/EC of the European Parliament and of the Council (EU Registry Regulation). The up to date information is accessible through the following link:

<https://www.register.dehst.de/crweb/report/public/publicReportList.do>

The publicly available information according to the decisions in more detail are described below.

12.4.2 13/CMP.1 Annex II Paragraph 45

The requested information is publicly available for each account in the German registry. The list of the information presented is provided in Annex 5 (chapter 21). The data of operator holding accounts (account type 120) can be viewed online at:

<https://www.register.dehst.de/crweb/report/public/accountOh.do>

The data of all accounts can be viewed online at:

<https://www.register.dehst.de/crweb/report/public/account.do>

Comprehensive search functionality is available.

12.4.3 13/CMP.1 Annex II Paragraph 46

There were two issuance of ERU in the reported year. One project about 66 ERU and another project about 143,426 ERU. A full list of all German JI projects is accessible through:

<https://www.register.dehst.de/crweb/report/public/project.do>

Respectively through

<https://www.jicdm.dehst.de/promechg/pages/project1.aspx>

12.4.4 13/CMP.1 Annex II Paragraph 47

The information requested in 13/CMP.1 Annex II Paragraph 47 (a), (d), (f) and (l) is considered to be confidential due to European law and therefore not publicly available. The information requested in the other items is given in the following:

(b) There was not any issuance of AAU in 2009. All issued AAU can be seen by the link below:

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_1

(c) The total number of issued ERU in the reported year is 143,492.

(e) No RMU was issued in the reported year.

(g) No ERU, CER, AAU, and RMU were cancelled on the basis of activities under Article 3, paragraphs 3 and 4 in the reported year.

(h) No ERU, CER, AAU, and RMU were cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1 in the reported year.

(i) No RMU was cancelled in the reported year. 66 ERU, 193,961 CER, and 1,208 AAU were voluntarily cancelled.

(j) No ERU, CER, AAU, and RMU were retired in the reported year.

(k) There were not any carry over of ERU, CER, AAU or RMU from the previous commitment period.

12.5 Calculation of the Commitment Period Reserve

12.5.1 13/CMP.1 Annex I.E Paragraph 18

The initial Commitment Period Reserve (CPR) has not changed and is still 4,381,287,024 CO₂ eq. The German registry did not violate the Commitment Period Reserve (CPR) during the reported year. The calculation of the Commitment Period Holdings (CPH) is performed in the German registry software according to the computation instructions of the secretariat.

The German registry software has been prepared for keeping of the CPR. Any transaction that would breach the CPR would be rejected by the German registry. This functionality has been thoroughly tested in our own testing and together with secretariat (Annex H test).

At the beginning of 2009 the Commitment Period Holdings (CPH), as a sum of all CPR relevant Kyoto units, was 4,915,596,720. At the end of the year it was 4,960,399,152. In 2009 the CPH minimum was 4,894,367,268 units and the maximum 5,004,076,049. The arithmetic mean calculated by including all transactions was 4,923,177,071. Neither a trend nor a risk had to be stated to breach the CPR in 2009. No transaction had to be rejected because of an underrun of the CPR. Please see the figure below.

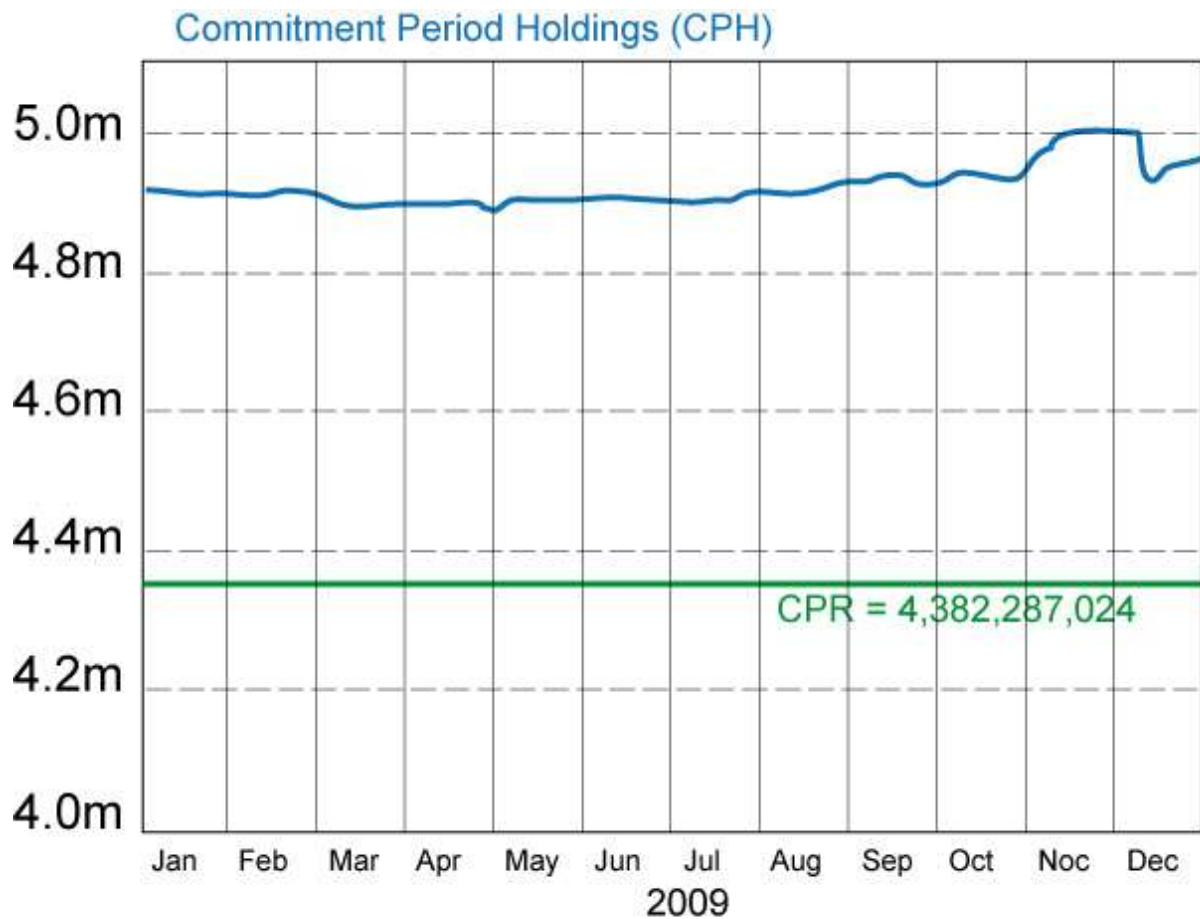


Figure 61: Commitment Period Holding (CPH) in 2009

The present status of the CPR is publicly available and can be found at:

<https://www.register.dehst.de/crweb/report/public/cpr.do>

The system keeps track of all incoming and outgoing CPR relevant transactions. The status is updated after every completed transaction.

13 INFORMATION ON CHANGES IN THE NATIONAL SYSTEM

The main focus of work in the past year was on consolidation and implementation of the improvements, made in 2009, in institutionalisation of the National System. In particular, the administrative agreement with the Federal Statistical Office was implemented for the first time, and the relevant data requirements for emissions reporting were again reviewed and updated.

Discontinuation of Fachserie 4 Reihe 8.1 of the Federal Statistical Office (statistics on the iron and steel sector)

As a result of the expiration of the relevant legal basis (Act on raw materials statistics – Rohstoffstatistikgesetz), the Federal Statistical Office discontinued data collection for, and publication of, Fachserie 4 Reihe 8.1 (statistics on the iron and steel sector) as of 31 December 2009. Consequently, the availability of bases for calculation for that area has worsened markedly.

The Federal Ministry of Economics and Technology (BMWi), the responsible ministry, is currently reviewing the possibility of using alternative data sources to close this data gap. The relevant possibilities being reviewed by the ministry include concluding co-operation agreements with the relevant companies and the relevant association, and issuing new laws for future resumed publication of the pertinent official statistics.

Changes in the National System with regard to Articles 3.3 / 3.4:

the changes in the National System, in the area of agriculture and LULUCF, are described in Chapter 1.2.1.4. As part of the changes, the remarks provided in Articles §§ 10 and 62 in the 2008 annual review report (ARR) have been addressed.

14 INFORMATION ON CHANGES IN THE NATIONAL REGISTRIES

Germany had no previously identified questions of implementation pertaining to transactions.

14.1 Change to the database or the capacity of National Registry

14.1.1 15/CMP.1 Annex I.E paragraph 17

The German registry had 130 discrepant transactions. In most cases, the reason was an inconsistency in the transaction status: completed on the German registry, but just accepted and consequently incomplete on the ITL, CITL or transferring registry. Users of the German registry were able to initiate a new transaction although the involved units had not been released on the ITL, CITL or transferring registry. The result was a rejection of those transactions (error codes 4003 and 4010) by the ITL. The high number results from several attempts of same users. The issue was caused by the message flow defined in older DES versions and is not caused by an error of the German registry software. In 2009 the UNFCCC proposed a revised message flow to prevent such situations. The new message flow has been implemented in the German registry since November 2010.

Germany had no previously identified questions of implementation pertaining to transactions.

On 5th of November 2009 a voluntary cancellation in error occurred by an account holder. At 26th November 2009 Germany sends a formal request for the reversal of this transaction to the ITL-Administrator. This request was approved by the ITL-Administrator at 1st December 2009. After having successfully tested the reversal procedure, the manual intervention on the production system (ITL, National Registry, and CITL) was scheduled for the 15th December. Due to technical problems in the CITL the whole procedure took until 17th December.

14.2 Change to the database or the capacity of National Registry

14.2.1 15/CMP.1 Annex II.E Paragraph 32.(c)

The database structure was extended to cover the below described additional functionality.

There was no change in the capacity of the national registry. As reported for 2008 Germany implemented a defragmentation tool to join single unit blocks if they fit to each other in order to minimise the fragmentation of unit blocks. The defragmentation algorithm was improved in 2009.

14.2.1.1 New user roles

Three new roles were implemented: verifier, technical admin, and additional authorised representative. The functionality of the registry software was enlarged to support the addition role of the verifiers in the EU Emission Trading System (EU ETS). Verifiers are linked to installations and they are able to enter and change the annual verified emissions figure for specified installations and specific years.

In addition the new role of a technical administrator and additional authorised representative were implemented. New data fields were added. Database relations and access rights were revised.

14.2.1.2 Confidential information of account representatives

Account holders are able to choose if parts of the personal information of their authorised representatives are confidential or not. If so, the public reports do not display this as confidential marked information. For this a new data field was added to the user's table.

14.2.1.3 Restricted transactions to national accounts

From person holding accounts (account type 121) and from operator holding accounts (account type 120) it is not longer possible to make an internal transaction (transaction type 03-00) to a national account (account type 100). This possibility was blocked because of too many faulty and not assignable transactions in the past. If it is necessary to make such an transaction, a kind of transaction form (very similar to a notification) is send to the account were the necessary transaction details are filled out with default values like acquiring account, unit type, amount and also a reference number. New tables and data fields are added to the database.

14.3 Change of conformance to technical standards

14.3.1 15/CMP.1 Annex II.E Paragraph 32.(d)

New transaction types were introduced with the amendment to the EU Registry Regulation in the EU Emission Trading System (EU ETS) in 2008. These new transaction types are 10-61 (Conversion of surrendered allowances for retirement from 2008 to 2012 onwards) and 10-62 (Conversion of unallocated allowances for retirement from 2008 to 2012 onwards). In addition the Account Management Web Service was changed into a generic web service. For this the DES (Data Exchange Standards for Registry Systems under the Kyoto Protocol), Annex M (EU-ETS Supplementary Scheme Web Service Documentation) was also changed. Germany passed the confirmation test on 29 September 2009. This test was run with the EU Commission. The test result was accepted by the UNFCCC. The new generic web service was introduced to implement an automated NAP Change functionality, a fee management, and to classify personal information as confidential.

14.4 Change of discrepancies procedures

14.4.1 15/CMP.1 Annex II.E Paragraph 32.(e)

For the time being there was no need to develop additional procedures or measures to minimize the risks described in 15/CMP.1 Annex II.E Paragraph 32. (e). Under (f) we describe an additional role of the technical administrator that was implemented in 2009. This measure is not a consequence of an incident but an additional measure to minimize risks.

14.5 Change of Security

14.5.1 15/CMP.1 Annex II.E Paragraph 32.(f)

By the following various measures the security of the software was increased.

14.5.1.1 User information at a successful login

In case of a successful login the users can select that they are informed about this event via an email straight away.

14.5.1.2 User information at login behaviour

All users are informed about their last successful login, the last unsuccessful login, and the number of all successful logins.

14.5.1.3 User information at transaction status

If there is a new transaction or a change to the status of a transaction, users can select if they are informed about this.

14.5.1.4 Additional authorised representative

Account holders are able to choose an additional authorised representative in order to approve induced transactions by the 1st or 2nd authorised representative. This implemented a four eyes principle which reduced the possibility of transactions in error to a minimum.

14.5.1.5 Technical administrator

An additional role, called technical administrator, was implemented in order to improve the security. This is a restricted access that allows the technical administrator only to change account data, the data of representatives, to perform daily maintenance (status of transactions). A technical administrator cannot induce a transaction. Only actual administrators are able to perform all functions including issuance, conversions, transactions, cancellations, retirement and others transaction types. This measure reduces the probability of faulty transactions to a minimum one.

14.5.1.6 Automated interface

In order to support traders and intense users and automated interface was implemented. This automated interface needs an own banking system on the user's side in order initiate requests. The communication interface is established through xml. The authentication takes place by software certificates. The provided functionality covers three main functions:

- to query the account balance
- to query the list of historical transactions
- to initiate new transactions

15 INFORMATION REGARDING MINIMISATION OF NEGATIVE IMPACTS PURSUANT TO ARTICLE 3 (14)

The following tables list various policies and measures (sorted by sectors), along with their direct and indirect effects on developing countries.

Most of the measures that would be carried out in Germany would not be expected to have direct effects on developing countries. In the case of other measures, the expected effects are largely considered to be positive. Such effects, for example, would include establishment of technical and administrative structures for climate protection.

Almost all of the possible indirect effects are also considered to be positive. Such effects would include beneficial impacts on energy supplies and prices in co-operating countries.

The only possible negative effect would occur via promotion of non-sustainably produced biofuels. Such promotion could lead to destruction of, or adverse shifts in, resources in developing countries. In future, such effects are to be prevented via implementation of pertinent sustainability ordinances.

Table 274: Cross-cutting measures

Measure	Direct effects	Indirect effects
Emissions trading	none	
CDM	positive	
Jl	none	
Energy/CO ₂ taxes	none	

Table 275: Energy-policy measures

Measure	Direct effects	Indirect effects
Promotion of renewable energies	none	<u>Positive:</u> Potential reduction of dependence on fossil fuels; Potential improvement of electricity supplies in rural areas; Improvement of air quality
Promotion of biofuels	none	<u>Negative:</u> If biofuel imports lead to destruction of forests and other CO ₂ sinks, or if biofuel-biomass cultivation leads to food shortages / food-price increases in developing countries. <u>Positive:</u> Economic development
Promotion of energy efficiency	none	<u>Positive:</u> Can lead to reduced energy costs and improved air quality
Promotion of CHP systems	none	<u>Positive:</u> Helps reduce energy costs

Table 276: Agriculture

Measure	Direct effects	Indirect effects
Orienting of subsidies to food security and animal-welfare standards instead of to production quantities	<u>Positive:</u> Encourages competition in agriculture	none
Improved management of animal waste	none	none
Biogas use / anaerobic fermentation	none	<u>Positive:</u> Comparatively cheap energy source.

Table 277: Forestry

Measure	Direct effects	Indirect effects
Reforestation	none	<u>Positive:</u> Less deforestation
Sustainable forest management	none	none

Table 278: Waste recycling / treatment

Measure	Direct effects	Indirect effects
CH₄ separation from waste and sewage sludge	none	<u>Positive:</u> Cost-effective energy source
Composting	none	none

16 FURTHER INFORMATION

This Chapter is currently not required.

17 ANNEX 1: GERMAN GREENHOUSE GAS INVENTORY - KEY SOURCES

In accordance with the *"IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories"*⁸⁴ (Good Practice Guidance), the Parties to the Framework Convention on Climate Change, and, in future, the Parties to the Kyoto Protocol as well, are obliged to calculate and publish annual emissions data.

These emissions inventories must be readily comprehensible (transparency); must be calculated in a consistent manner in the time series since 1990 (consistency); must be evaluated uniformly at the international level via application of the prescribed calculation methods (comparability); must contain all the relevant emission sources and sinks in the reporting country (completeness); must be evaluated with error specification; and must undergo ongoing internal and external quality management (accuracy).

To facilitate concentrating the many and detailed activities and resources required for this purpose on the inventory's principal source categories, the IPCC has introduced the term "key source". Key sources are source categories which are highlighted in the national inventory system because their emissions have a significant influence on total emissions of direct greenhouse gases, either in terms of absolute emissions, or as a contribution to the emissions trend over time, or in both ways.

In its chapter 7, the Good Practice Guidance specifies the methods to be applied for identifying key sources. These methods include inventory analysis for one year (Tier 1 Level Assessment), time-series analysis of inventory data (Tier 1 Trend Assessment) and detailed analysis of inventory data with error evaluation (Tier 2 Trend Assessment with consideration of inaccuracies).

Such analyses must always be carried out using two procedures. In a first procedure, only emissions from sources are evaluated, and storage in sinks is not considered. In a second procedure, emissions storage in sinks is then included (without any consideration of whether it is positive or negative). As would be expected, the two results differ. Pursuant to the Good Practice Guidance, both results must be taken into account in determination of key sources.

For identified key sources, the Parties are then required to use highly detailed calculation methods (Tier 2 or higher; the relevant methods are also specified in the Good Practice Guidance). Should direct use of such methods prove impossible, for whatever reason (e.g. data are not available for the required input variables, etc.), Parties are required to prove that the methods applied nationally achieve at least a comparable degree of accuracy in the calculation result. Such proof, as well as the key-source analysis performed overall, must be outlined in the national inventory report to be prepared annually.

⁸⁴ This Report was produced as a response to a suggestion by the UN Framework Convention on Climate Change to the Intergovernmental Panel on Climate Change (IPCC). The relevant effort called for completing determination of uncertainties in inventories and for preparing a report on "good practice" in inventory management.

It was prepared with the aim of supporting countries in preparing their own emissions inventories. The aim was to avoid over-valuation or under-valuation of the results and to reduce the inaccuracies of the inventories as far as possible.

This report has been published in the Internet at: <http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm>

17.1 Description of the method for identifying key sources

The results of the key-source analysis based on the two Tier 1 methods (Level and Trend), and on the Tier 2 method, are outlined below. In this context, we call attention to the description of the underlying methods in the *Good Practice Guidance*. In a departure from that source's proposal for structuring included source categories, a greater degree of detail was chosen for the present analysis. Annual emissions inventories were divided, in keeping with their CO₂-equivalent emissions, into a total of 120 individual activities.

17.1.1 Tier 1 approach

As a result of **level analysis**, those source categories responsible for 95 % of total national emissions (as CO₂-equivalent emissions), in the Kyoto Protocol's base year and in the current year, are identified as key sources (●). Calculations were performed using formula 7.1 from the Good Practice Guidance.

In the source category summary used in this analysis, a total of 31 key sources were identified in 2009 using this approach (cf. Table 7, Chapter 1.5).

As a result of **trend analysis**, those source categories which have made a particular contribution to changes in total greenhouse gas emissions in 2009, in terms of the development of their contribution since the base year, are identified as key sources (●). In this respect, it is irrelevant whether such changes have led to a reduction or an increase in total emissions. Calculations were performed using formula 7.2 from the Good Practice Guidance.

Tier 1 Trend analysis, using source-category structuring as described, identified a total of 34 key sources (cf. Table 7 Chapter 1.5).

17.1.2 Tier 2 approach

The key source analysis pursuant to the Tier 2 approach is based on the results of current uncertainties determination in accordance with Tier 1. Because of the high level of overhead it entails, detailed Tier 2 uncertainties analysis is carried out only every 3 years in Germany. It was last carried out last year.

The results provided extensive confirmation of the results of the pertinent Tier 1 key-source analyses. In addition, the uncertainties for CH₄ emissions for manure management, and for CO₂ emissions for the Settlements and Wetlands source categories, are considered to be very high.

17.1.3 Key-source analysis for Kyoto reporting

The following CRF Table NIR.3 summarises information relative to key-source analysis in Kyoto reporting. Additional information is presented in Chapter 1.5.2.

Table 279: KP CRF Table NIR.3: Summary Overview for Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol

Key Categories of Emissions and Removals	Gas	Criteria used for Key Category Identification			Comments (3)
		Associated category in UNFCCC inventory(1) is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory (1), (4) (including LULUCF)	Other(2)	
Specify key categories according to the national level of disaggregation used(1)					
Forest Management	CO ₂	Forest Land remaining Forest Land	Yes		
Afforestation and Reforestation	CO ₂	Land converted to Forest Land	Yes		

(1) See section 5.4 of the IPCC good practice guidance for LULUCF.

(2) This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.

(3) Describe the criteria identifying the category as key.

(4) If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

18 ANNEX 2: DETAILED DISCUSSION OF THE METHODOLOGY AND DATA FOR CALCULATING CO₂ EMISSIONS FROM COMBUSTION OF FUELS

18.1 The German Energy Balance

In the Federal Republic of Germany, energy statistics are published by numerous agencies, and these statistics can differ in terms of their presentation, scope and aggregation. On an annual basis, the associations in the German energy sector, working in co-operation with economic research institutes, and in the framework of the Working Group on Energy Balances (AGEB), combine the relevant data to form a complete picture. They then make the data available to the public in the form of Energy Balances. The Energy Balances of the Federal Republic of Germany are the central data foundation for determining/preparing energy-related emissions, scenarios and forecasts of the impacts of energy-policy and environmental-policy measures.

The complete Energy Balances for the years since 1990 are available in the Internet at:

<http://www.ag-energiebilanzen.de/daten/inhalt1.php>

The members of the Working Group on Energy Balances (AGEB) include (as of: September 2008):

- Bundesverband der deutschen Energie- und Wasserwirtschaft e.V. (BDEW) (Association of the German Energy and Water Industry), Berlin;
- Deutscher Braunkohlen-Industrie-Verein e.V. (DEBRIV) (German Lignite Industry Association), Cologne;
- Gesamtverband des deutschen Steinkohlenbergbaus (GVSt) (General Association of the German Hard Coal Industry), Essen;
- Mineralölwirtschaftsverband (MWV) (Association of the German Petroleum Industry), Hamburg;
- Verband der Industriellen Energie- und Kraftwirtschaft e.V. (VIK) (Association of Industrial Energy and Power Producers), Essen;
- Deutsches Institut für Wirtschaftsforschung (DIW) (German Institute for Economic Research), Berlin;
- Energiewirtschaftliches Institut an der Universität Köln (EWI) (Institute of Energy Economics at the University of Cologne), Cologne;
- Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI) (Rhine-Westphalian Institute for Economic Research), Essen.

Since the 1995 balance year, overall responsibility for preparation of Energy Balances has lain with the German Institute of Economic Research (DIW; Berlin); since 2002, the DIW has carried out relevant work in co-operation with EEFA (Energy Environment Forecast Analysis GmbH). Overall, with due regard for the available data, the Energy Balances provide a reliable picture of energy production and use in the German economy.

The most important sources are listed in Table 280. In a number of categories, furthermore, experts personally provide relevant data – in categories, for example, such as non-energy-related consumption by the chemical industry.

Table 280: Data sources for the Energy Balances:

All energy resources	Federal Ministry of Economics and Technology (BMWi) Electricity Industry Department – Annual statistical reports Gas Industry Department – Annual statistical reports Federal Office for Statistics Annual figures for the manufacturing industry Fachserie (Specialised series) 4 Manufacturing sector - Series 3.1 Production in the manufacturing industry - Series 4.1.1 Employment and revenue of manufacturing-sector companies - Series 6.4 Power-production facilities of mining and manufacturing companies Fachserie (Specialised series) F4 Foreign trade - Series 2 Foreign trade by types of goods and countries Selected figures on the energy industry Bundesverband der deutschen Energie- and Wasserwirtschaft e.V. (BDEW) (Association of the German Energy and Water Industry) BDEW annual statistics (Jahresstatistik) BDEW surveys on use of renewable energy resources Market research results, company data, calculations by the Working Group on Energy Balances (AGEB)
Hard coal and lignite	Statistics from the Kohlenwirtschaft e.V. (Coal Industry Association) Coal mining in the energy industry of the Federal Republic of Germany – annual reports Coal industry statistics Sales statistics and other unpublished energy statistics
Petroleum	Federal Office of Economics and Export Control Official Petroleum Statistics for the Federal Republic of Germany Mineralölgewerkschaft e.V. (MWW) (Association of the German Petroleum Industry) Petroleum Statistics – Annual Reports Wirtschaftsverband Erdöl- and Erdgasgewinnung e.V. (Association of the Petroleum and Natural Gas Extraction Industry) Annual reports Federal Ministry for Food, Agriculture and Consumer Protection Gasoil consumption in agriculture
Gases	Federal Statistical Office, Düsseldorf branch Iron and Steel Statistics: Fuel, Gas and Electricity Statistics Wirtschaftsverband Erdöl- and Erdgasgewinnung e.V. (Association of the Petroleum and Natural Gas Extraction Industry) Annual reports Statistics from the Kohlenwirtschaft e.V. (Coal Industry Association) Gas Statistics Deutscher Verband Flüssiggas e.V. (German Liquid Petroleum Gas Association) The LPG Market – Annual Reports
Other energy resources	Arbeitsgemeinschaft Fernwärme e.V. (Working Group on District Heating) District heating reports
"Non-fuels"	Mineralölgewerkschaft e.V. (MWW) (Association of the German Petroleum Industry) Verband der Chemischen Industrie e.V. (VCI) (Chemicals Industry Association)

(ZIESING et al, 2003)

18.2 Structure of the Energy Balances

The Energy Balances, which are structured in matrix form, provide an overview of the interconnections within the energy sector. As a result, they not only provide information about consumption of energy resources in the various source categories, they also show the

relevant flows of such resources, from production to use in the various production, transformation and consumption areas (cf. Figure 63). The **production balance** shows:

- Domestic production
- Imports
- Removals from stocks
- Exports
- Maritime bunkering
- Additions to stocks

of energy resources, and it summarises them under **primary energy consumption**. The primary Energy Balance provides the basis for calculations under the IPCC reference procedure (PROGNOS, 2000). The **usage balance** provides a key basis for preparation of emissions inventories. The usage balance can also be used for determination of primary energy consumption. It comprises:

- The transformation balance
- Flaring and line losses
- Non-energy-related consumption, and
- Final energy consumption.

Differences between the production and usage balances are compensated for in the position "Statistical differences".

The **transformation balance**, part of the usage balance, shows what energy resources are transformed, as well as what other resources they are transformed into. The transformation production shows the results of such transformation. Energy transformation can involve either substance modification – such as transformation of crude oil (transformation input) into petroleum products (transformation production) – or physical transformation – such as combustion of hard coal (transformation input) – in power stations, for production of electrical energy (transformation production). The energy consumption in the transformation sector shows how much energy was needed for operation of transformation systems (the transformation sector's own consumption). The transformation balance is broken down by facility type; a total of 12 different types of facilities are considered.

Energy Balance until 1994	Line	Energy Balance of the Federal Republic of Germany as of 1995	Line
Primary energy balance		Primary energy balance	
Domestic production	1	Domestic production	1
Imports	2	Imports	2
Removals from stocks	3	Removals from stocks	3
Domestic energy production	4	Domestic energy production	4
Exports	5	Exports	5
Maritime bunkering	6	Maritime bunkering	6
Additions to stocks	7	Additions to stocks	7
Domestic primary energy consumption	8	Domestic primary energy consumption	8
Transformation balance		Transformation balance	
Transformation Input		Transformation Input	
Coking plants	9	Coking plants	9
Municipal gas works	10	Hard-coal and lignite briquetting plants	10
Hard-coal briquetting plants	11	Public thermal power stations (not including CHP stations)	11
Lignite briquetting plants	12	Industrial thermal power stations	12
Public thermal power stations	13	Nuclear power stations	13
Mine power stations	14	Hydroelectric power stations, windpower and photovoltaic systems	14
Other industrial thermal power stations	15	Public thermal power stations	15
Nuclear power stations	16	District heating stations	16
Hydroelectric power stations	17	Blast furnaces	17
Thermal power stations, district heating stations	18	Refineries	18
Blast furnaces	19	Other energy producers	19
Refineries	20	Total transformation input	20
Other energy producers	21	Transformation Emissions	
Total transformation input	22	Coking plants	21
Transformation Emissions		Hard-coal and lignite briquetting plants	22
Coking plants	23	Public thermal power stations (not including CHP stations)	23
Municipal gas works	24	Industrial thermal power stations	24
Hard-coal briquetting plants	25	Nuclear power stations	25
Lignite briquetting plants	26	Hydroelectric power stations, windpower and photovoltaic systems	26
Public thermal power stations	27	Public thermal power stations	27
Mine power stations	28	District heating stations	28
Other industrial thermal power stations	29	Blast furnaces	29
Nuclear power stations	30	Refineries	30
Hydroelectric power stations	31	Other energy producers	31
Thermal power stations, district heating stations	32	Total transformation emissions	32
Blast furnaces	33	Consumption in energy production and in transformation sectors	
Refineries	34	Coking plants	33
Other energy producers	35	Hard-coal mines, hard-coal briquetting plants	34
Total transformation emissions	36	Lignite mines, briquetting plants	35
Consumption in energy production and in transformation sectors		Power stations	36
Hard-coal mines, hard-coal briquetting plants	37	Oil and gas production	37
Coking plants	38	Refineries	38
Municipal gas works	39	Other energy producers	39
Lignite mines, briquetting plants	40	Total energy consumption in the transformation sector	40
Power stations	41	Flaring and line losses	41
Oil and gas production	42		
Refineries	43	Domestic energy supply and transformation balance	42
Other energy producers	44	Non-energy-related consumption	43
Total energy consumption in the transformation sector	45	Statistical differences	44
Flaring and line losses, evaluation difference	46	Energy consumption (per sector)	
		Final energy consumption	45
Domestic energy supply and transformation balance	47	Non-metallic minerals, other mining	46
Non-energy-related consumption	48	Food and tobacco	47
Statistical differences	49	Paper	48
Energy consumption (per sector)		Primary chemicals	49
Final energy consumption	50	Other chemical industry	50
Other mining	51	Rubber and plastic products	51
Non-metallic minerals	52	Glass and ceramics	52
Iron and steel	53	Processing of non-metallic minerals	53
Iron and steel foundries (including malleable casting)	54	Metal products	54
Drawing shops and cold rolling mills	55	Non-ferrous metal products and casting	55
Non-ferrous metal products and casting	56	Metal processing	56
Chemical industry	57	Machine tools	57
Pulp and paper	58	Automotive industry	58
Rubber processing	59	Other industrial sectors	59
Other basic materials and producer's goods	60	Total mining, extraction of non-metallic minerals, manufacturing	60
Basic materials and producer's goods	51-60	Railway transport	61
Machine tools	61	Road transport	62
Automotive, aircraft and spacecraft	62	Air transport	63
Electrical engineering, precision mechanics, optics	63	Coastal and inland shipping	64
Ironware, tinware and metalware	64	Total transport	65
Other manufacturing of industrial goods	65	Households	66
Manufacturing of industrial goods	61-65	Commerce, trade, services and other consumers	67
Glass and fine ceramics	66	Military agencies	68
Production of plastic products	67		
Textiles	68		
Other manufacturing of consumables	69		
Manufacturing of consumables	66-69		
Sugar industry	70		
Other food industry	71		
Drink industry	72		
Food and drink industry	70-72		
Other mining and manufacturing, total	73		
Railway transport	74		
Road transport	75		
Air transport	76		
Coastal and inland shipping	77		
Total transport	78		
Total households and small consumers	79		
Military agencies	80		

Source: AGEb, 2003

Figure 62: Line structure of Energy Balances until 1994 and as of 1995

Non-energy-related consumption, as a component of the consumption balance, is shown as a total, without allocation to facility types or branches of industry. It describes which energy resources are used as raw materials (e.g. in the chemicals industry, transformation of energy resources into plastics).

Finally, the consumption balance indicates the final consumption sectors in which energy is transformed into the useful energy ultimately needed (such as power, light, room and process heating) (**final energy consumption**). This includes industry, sub-divided into 14 sectors, transport, households and commercial use, trade, services and other consumers (including agriculture).

Figure 63 shows the structure of the production and consumption balances in the energy balances until 1994 and as of 1995.

Energy resource structure in energy balances ...			
Through 1994		As of 1995	
Hard coal	HC coal HC coke HC briquettes HC raw tar HC pitch HC other Crude benzene	Hard coal	HC coal HC briquettes HC coke Other HC products
Lignite	L coal L briquettes L coke L coal dust Hard lignite	Lignite	L coal L briquettes Other L products Hard lignite
Other solid fuels	Firewood Peat Sewage sludge	Petroleum	Oil Gasoline Raw gasoline Jet kerosine Diesel fuel Heating oil, light Heating oil, heavy Petrol coke LP gas Refinery gas Other petroleum products
Petroleum	Oil Gasoline Raw gasoline Avgas Jet kerosene Diesel Heating oil, light. Heating oil, heavy Petrol coke Other petroleum products	Gases	Coke-oven and city gas Blast-furn. & converter gas Natural gas, petroleum gas Pit gas
Gases	LP gas Refinery gas Coke-oven gas Blast-furnace gas Natural gas Petroleum gas Pit gas Landfill gas	Renewable energies	Hydropower Wind and photovol. systems Waste and other biomass Other renewable energies
Electricity and other energy resources	Electricity Hydropower Nuclear power District heat Other energy resources	Electricity and other energy resources	Electricity Nuclear power District heat
Total energy resources	Primary energy resources Secondary energy resources Total	Total energy resources	Primary energy resources Secondary energy resources Total

Source: ZIESING et al, 2003

Figure 63: Energy resources in the Energy Balance of the Federal Republic of Germany

The energy flow in the Energy Balances is depicted for 30 energy resources. These energy resources can be allocated to the following main groups:

- Hard coal,
- Lignite,
- Petroleum (including LPG and refinery gas),
- Gases (coke oven and blast furnace gas, natural gas, firedamp, excluding landfill gas and the aforementioned gases),
- Renewable energy resources (including waste fuels),
- Electrical power and other energy resources.

Energy balances from the year 1950 on are available for the Federal Republic of Germany in the territorial delimitation prior to 3 October 1990. Moreover, Energy Balances have been drawn up for the years 1990 to 1994 separately for the old and new *Länder*, and for Germany as a whole. With the conversion of the official statistics to the classification of industrial sectors (*FEDERAL STATISTICAL OFFICE*, 2002c), since 1995 only Energy Balances for Germany as a whole (in the territorial delimitation of 3 October 1990) have been submitted. The main group structure (until 1994 and as of 1995) is shown in Figure 63. Via the "Renewable energies" satellite balance, renewable energies are further broken down as of 1996 (AGEB 2003).

As of the year 2000, the energy-resource structure in the area of renewable energies / waste was changed: hydroelectric and windpower, along with photovoltaic systems, were combined, and waste/biomass was divided into renewable and non-renewable fractions. Since 2004, non-recyclable waste and waste heat are also listed under final-energy consumption within the Energy Balance.

In the Energy Balance, fuels / energy resources are listed in *natural units*, including tonnes (t) for solid and liquid fuels, cubic metres (m³) for gases, kilowatt hours (kWh) for electrical power, and joules (J) for waste, renewable energy sources, nuclear power and district heating. In order to render the data comparable and suitable for addition, all values are converted into joules (J) using calorific value tables and conversion factors. Unlike gas statistics or international Energy Balances, the Energy Balance lists even gases in terms of calorific value.

To date, Energy Balances through 2008 have been published. Previously, the Federal Environment Agency has met requirements for currentness, in emissions reporting, by preparing provisional Energy Balances on the basis of the evaluation tables. For the 2011 report, the Working Group on Energy Balances (AGEB), for the first time, has provided the Federal Environment Agency with a complete provisional Energy Balance (for the year 2009).

18.3 Methodological issues: Energy-related activity data

Essentially, the inventories for air pollutants and greenhouse gases prepared by the Federal Environment Agency are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB). The data required for emissions calculation can be read directly from Energy Balance lines 11, 12, 15, 16, 40, 60, 65 and 68. For biomass fuels, EB lines 14 and 19, depending on the fuel in question, also have to be used in calculation.

In a few cases, the special requirements pertaining to emissions calculation, and the need to assure the completeness of data, necessitate a departure from the above-described system, and additional data have to be added:

- The emissions-relevant fuel inputs for lignite drying have to be calculated out of EB line 10. A precise description of source category 1.A.1.c is provided in Chapter 3.2.8.2.
- Natural gas inputs in compressors, for the years 1995-2002, can be read directly from the Energy Balance (EB line 33). For the years 1990-1994, and for the period as of 2003, the values have to be calculated outside of the Energy Balance. The relevant method is described in Chapter 3.2.10.5.2 (source category 1.A.3.e).
- For systematic reasons, and for reasons having to do with a focus on energy production, the Energy Balance does not list incinerated waste quantities completely for all relevant years. In this area as well, therefore, the lacking data have to be added from waste statistics. Relevant explanations are provided in Chapter 3.2.6.2 (source category 1.A.1.a) and in Chapter 3.2.9.11.2 (source category 1.A.2.f Other).
- Firewood use in the source categories commercial and institutional is not listed in the Energy Balance and has to be added. A description of source category 1.A.4 is provided in Chapter 3.2.11.2.

In the Energy Balance, inputs of reducing agents, in pig-iron production, are listed in part as energy-related consumption, in EB line 54, and in part as transformation inputs, in EB line 17 (top-gas equivalent). Use of the related blast-furnace gas for energy production is listed in the relevant Energy Balance lines, 11, 12, 15, 33 and 54. To prevent double counting, the fuel inputs from blast furnaces, as listed in EB line 54, and the relevant top-gas equivalent, are not reported.

18.4 Uncertainties and time series consistency in the Energy Balance

In an endeavour to ensure that Energy Balances are always meaningful, it is necessary to make allowance for changes in the underlying statistics, for changes in the energy sector and for changes in requirements of data users. Such changes were made as early as the 1970s. Partly as a result of increasing energy-market liberalisation, and in conjunction with the formation of a European single market, the condition of the statistical energy database has worsened in recent years of change (ZIESING et al, 2003). With the introduction of the Act on Energy Statistics, which has been in force since 2003, the data basis has improved again, although the relevant other data collection has necessitated changes in the overall data structures. In 2009, the Energy Balances for 2003 through 2006 were revised. Changes were carried out in the areas of transformation inputs of natural gas, petroleum gas and renewable energies – in Energy Balance lines 11 (thermal power stations for the public power supply), 12 (industrial thermal power stations), 14 (hydroelectric power, wind-power, photovoltaic and other systems), 15 (heat/power stations for the public heat/power supply), 16 (district heating stations), 19 (other energy producers), 66 (residential) and 67 (commercial and institutional and other consumers). These changes also have impacts on the sum of transformation inputs and primary energy consumption (cf. DIW, EEFA, 2009: "Dokumentation zur Revision der Energiebilanzen für die Bundesrepublik Deutschland für die Jahre 2003 bis 2006" ("Documentation on revision of Energy Balances for the Federal Republic of Germany, for years 2003 to 2006")).

The changes affect both the data sources used – extensive transitions were made on the basis of public statistics – and allocation of fuel inputs to heat and power production in CHP systems. Separate listing of CHP systems in public statistics led to recalculations of Energy Balances, with the help of the relevant Finnish method. In only a few cases – such as mine-gas inputs in public power stations and inputs of hard coal and natural gas in district heating stations – do these two effects lead to noticeable discontinuities in the time series between 2002 and 2003. The available data for the period prior to 2002 cannot be improved retroactively, however.

The revision was also used for the purpose of taking account of data updates of the *Federal Statistical Office* and the Federal Office of Economics and Export Control (BAFA) that occurred after the publication of the Energy Balances. Also as part of the revision, the efficiencies for electricity production with use of biogenic fuels were brought into line, for the year 2003, with the efficiencies applied since 2004.

18.4.1 The base year 1990 and the Energy Balances for 1991 to 1994

The base year 1990 plays a key role in national emissions inventories, and it is especially important as a reference year for agreed emissions-reduction targets under climate protection policy. For Germany, admittedly, this is linked to the problem that the country did not have the same national territorial status throughout the entire year of 1990. Radical changes in the territory of the GDR and the new *Länder*, including profound economic woes and fundamental organisational/structural problems, greatly complicated the process of collecting energy statistics in eastern Germany for 1990. This also had certain repercussions for the old *Länder*, for which the AGEB was still able to prepare and publish balances in the conventional manner (ZIESING et al, 2003).

For the GDR / new German Länder, the Institut für Energetik (IfE) in Leipzig assumed the tasks of preparing an Energy Balance for 1990 that would be compatible with western German balances (IFE, 1991). In this effort, the Institute had access to a study, carried out under the direction of DIW Berlin (German Institute for Economic Research), whose aims included preparing suitable Energy Balances for the GDR for the years 1970 to 1989 (DIW, 1991). The AGEB Energy Balances, for the old German Länder, and the IfE Energy Balances, for the new German Länder, are being aggregated for the new Energy Balances prepared in the framework of the EUROSTAT project (ZIESING et al, 2003) for the year 1990 and for Germany as a whole. In keeping with the system in force as of 1995, some changes have been made in the original balances for 1990 and for the years 1991 to 1994 (cf. ZIESING et al, 2003). Furthermore, in keeping with the procedure used by international organisations (IEA, EUROSTAT, ECE), the so-called "efficiency approach" is used, instead of the formerly used "substitution approach", for Energy Balances for Germany since 1995. In addition, recalculations with the efficiency approach have been carried out back to the year 1990.

Due to a lack of suitable data, it was not possible to adapt differentiation of final energy consumption, by source categories, in the manufacturing sector. The applicable system for this area changed considerably in 1995, when a transition was made from the SYPRO manufacturing-sector system (Systematik des produzierenden Gewerbes) to the Classification of Economic Activities, edition 1993 (*FEDERAL STATISTICAL OFFICE*, 2002c).

These Energy Balances are seen as the primary energy statistics to be used in determining energy-related CO₂ emissions in Germany.

In revision of activity data for stationary combustion in 1990 in the new German Länder, some shifting of fuel inputs between Energy Balance lines resulted. The overall framework remained unchanged, however. This is described in 0.

18.5 Uncertainties in the activity data for stationary combustion systems

See NIR 2007, Chapter 13.6.

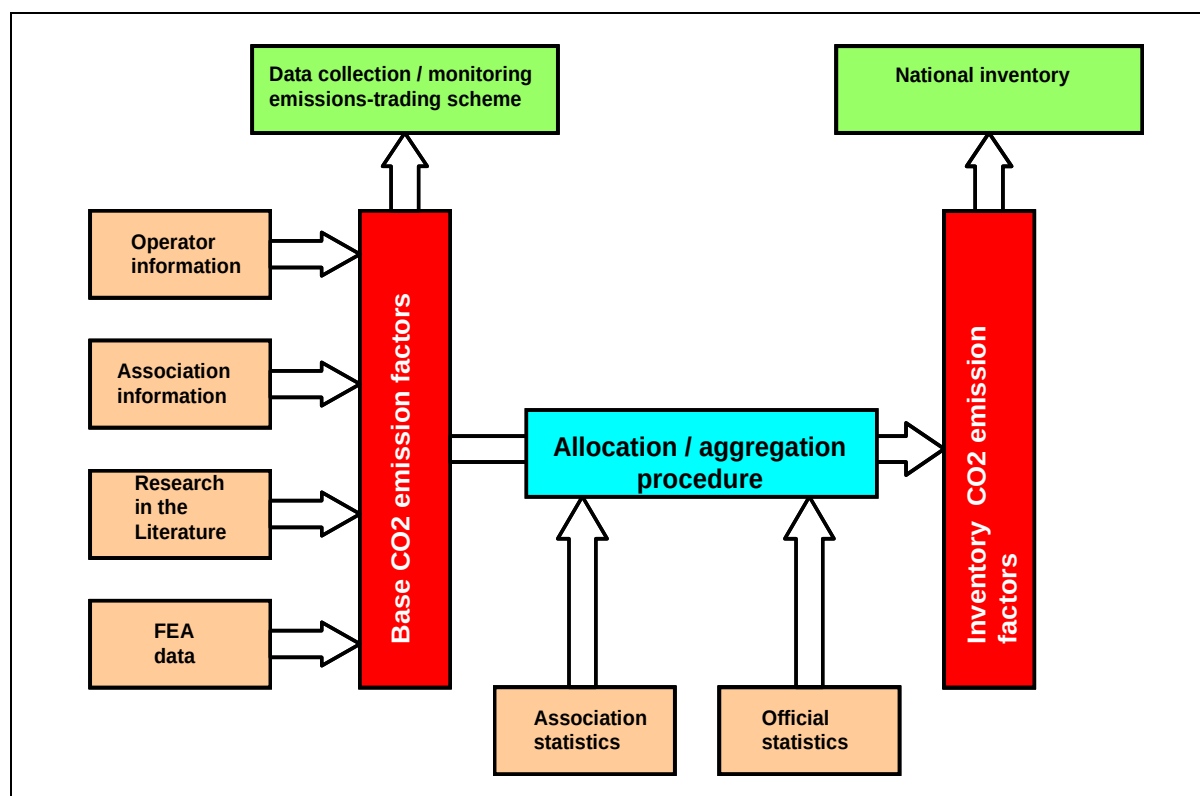
18.6 CO₂ emission factors

The emission factors on which the inventory is based were derived from the list of "CO₂-Emissionsfaktoren für die Erstellung der nationalen CO₂-Inventare" ("CO₂ emission factors for preparation of national CO₂ inventories"; Öko-Institut, 2004c).

18.6.1 Preliminary remarks on methods

In the framework of EU emissions trading, it is necessary to provide highly differentiated CO₂ emission factors for facility operators, to ensure that determination of facility-specific emissions is as precise as possible.

Since CO₂ emission factors for preparation of national inventories are considerably less finely differentiated, and emissions allowances must be allocated to facility operators on a cyclical basis, maximum consistency must be sought. Requirements pertaining to the ETS allocation periods thus fit with the need for consistency in inventory-calculation methods.



Source: Öko-Institut

Figure 64: Base and inventory emission factors for CO₂

With this in mind, a consistent concept for CO₂ emission factors was developed (Figure 64).

The system is based on a set of differentiated CO₂ emission factors that – for the most part – are geared to the requirements of the emissions-trading scheme (so-called "basic" emission factors for CO₂). These emission factors were developed on the basis of a range of very different data sources. The data include operator data, data provided by associations and data gained from literature research. In addition, in some areas data of the Federal Environment Agency were used, and such data are now being enhanced via the ETS database.

With the help of structural data from association statistics and (quasi-) official statistics, the basic emission factors for CO₂ are allocated and aggregated in such a manner that they can fit with the activity data that can be used to prepare the national inventories. Emission factors on such an aggregation and allocation level are then referred to as "inventory emission factors" for CO₂.

18.6.2 Basic emission factors for CO₂

Current information on basic emission factors is available at the Federal Environment Agency's Web site, at the following URL:

<http://www.umweltbundesamt.de/emissionen/publikationen.htm>

18.6.3 Determination of inventory emission factors for CO₂

With the basic emission factors for CO₂ (not including the area of secondary fuels), along with data on energy-consumption structures, the CO₂ emission factors are determined at the differentiation level required for national CO₂ inventories (cf. Table 281).

With regard to *hard coal*, it is initially assumed that anthracite is used in small combustion systems, in residential heat-generation systems licensed in accordance with provisions of the Technical Instructions on Air Quality Control (TA Luft), in the small consumption sector (as of 1995: commerce, trade, services / commercial and institutional) and by military agencies. No further differentiation is carried out for anthracite. Neither is any further differentiation carried out for use of ballast coal.

For determination of CO₂ emission factors for hard coal, an energy-related mix of German hard-coal production, differentiated by districts (Ruhr, Saar, Aachen, Lower Saxony) is assumed; data for such a mix are available via the Statistik der Kohlenwirtschaft (coal-industry statistics). The relevant district-specific emission factors are then used, on this basis, to calculate a weighted average. Then, a mix consisting of domestic production and imports (broken down by countries of origin) is obtained. The relevant database consists of the aforementioned domestic-production figures and, initially, detailed data from the Association of Coal Importers (Verein der Kohlenimporteure). For calculation of the import mix, all hard-coal imports, broken down by supplier countries, are adjusted to take account of relevant amounts of coke and coking coal, and of the relevant (small) amounts of imports of other hard-coal products, and then converted to energy content.

The mix for domestic hard-coal production, and that for imports, are linked via the import fraction of hard coal used. This fraction is based on data, provided by the Association of Coal Importers (Verein der Kohlenimporteure), on fractions of imported coal found in the various areas of application. It does not include uses in the iron and steel industry and in coking plants.

The basis for country-specific CO₂ emission factors that enter into the CO₂ emission factor for the import mix consists of (unweighted) averages for the relevant countries of origin. For German hard coal, corresponding production data are used for weighting.

No further differentiation was carried out for hard-coal briquettes and hard-coal coke.

For use of raw lignite in public-sector power stations, the district-specific figures for CO₂ emission factors are used directly. A mixed value covering the different relevant districts (Rheinland, Lausitz, Mitteldeutschland, Helmstedt, Hessen) is calculated solely for the area of raw-lignite inputs in district-heating stations.

Through subtraction of crude-lignite quantities used in public power stations, and of quantities used in product production, from total production and import quantities (imports are significant only in connection with use of hard lignite), a difference is obtained that represents crude lignite use by industry and commerce, trade and services. This figure can then be broken down, via calculations, by areas of origin.

STATISTIK DER KOHLENWIRTSCHAFT (coal-sector statistics) production data are also used as a basis for calculating weighted averages, for the old and new German Länder and for Germany as a whole, from separate data sets for the various lignite products (lignite briquettes, fluidised-bed coal, pulverised lignite, dry lignite and lignite coke).

No further aggregation is carried out for the CO₂ emission factors for all other fuels; the values shown in Table 281 are used. The following should be noted with respect to allocations:

- For the period 1990 to 1994, during which separate balances are drawn up for the old and the new German Länder, weighted CO₂ emission factors, differentiated according to old and new German Länder, are used where appropriate.
- For the period until 1994, the CO₂ emission factor for Russian natural gas is assumed for the new German Länder.
- Gas separated under high pressure from natural gas is only relevant for West Berlin (until 1995).

Table 281: Emission factors for CO₂ as of 1990, as derived for emissions reporting: energy

Fuel-based emission factors [t CO ₂ /TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Coal																				
Hard coal (Steinkohle)																				
Raw hard coal (power stations, industry)	93.3	93.4	93.4	93.4	93.4	93.4	93.5	93.6	93.7	93.7	93.7	93.9	94.0	94.0	94.0	94.0	94.2	94.1	94.3	94.3
Hard-coal briquettes	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Hard-coal coke	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Anthracite (heat market for households, commerce, trade, services)	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0
Ballast hard coal <i>old German Länder</i>	90.0	90.0	90.0	90.0	90.0															
Lignite (Braunkohle)																				
Raw lignite																				
Public district heating stations, Germany.						112.5	112.3	112.3	112.2	112.2	112.1	111.9	112.1	112.1	112.3	112.3	112.2	112.3	112.3	112.2
Industry, commerce, trade, services, Germany						109.5	111.9	112.9	112.8	111.8	112.4	111.9	112.1	112.0	111.9	111.4	110.6	111.6	110.7	110.7
<i>Old German Länder</i>	113.9	113.8	113.8	113.9	113.9															
<i>New German Länder</i>	108.8	108.1	107.8	108.0	108.3															
Public power stations; District:																				
Rheinland	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0
Helmstedt	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Hesse	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	NO	NO	NO	NO	NO	NO
Lausitz	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0
Mitteldeutschland	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0
Lignite briquettes Germany						100.0	100.0	99.9	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.6	99.6	99.8
<i>Old German Länder</i>	99.0	99.0	99.0	99.0	99.0															
<i>New German Länder</i>	99.7	100.0	100.0	100.0	100.3															
Lignite tar New German Länder	97.0	97.0	97.0	97.0	97.0															
Lignite dust and fluidised bed coal Germany						97.8	97.7	97.7	97.8	97.9	98.0	98.0	97.9	97.9	97.9	98.0	98.0	97.9	98.0	98.0
<i>Old German Länder</i>	98.0	98.0	98.0	98.0	98.0															
<i>New German Länder</i>	96.7	96.6	96.8	97.5	97.1															
Lignite coke	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
Hard lignite	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0

Fuel-based emission factors [t CO ₂ /TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Petroleum																				
Crude oil	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Petrol	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Raw gasoline Germany						80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
<i>Old German Länder</i>	80.0	80.0	80.0	80.0	80.0															
<i>New German Länder</i>	74.0	74.0	74.0	74.0	74.0															
Kerosene	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Aircraft fuel	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3
Diesel fuel Germany						74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
<i>Old German Länder</i>	74.0	74.0	74.0	74.0	74.0															
<i>New German Länder</i>	73.0	74.0	74.0	74.0	74.0															
Light heating oil Germany						74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
<i>Old German Länder</i>	74.0	74.0	74.0	74.0	74.0															
<i>New German Länder</i>	73.0	74.0	74.0	74.0	74.0															
Heavy heating oil	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0
Petroleum	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Petrol coke	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0
LP gas Germany						65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
<i>Old German Länder</i>	65.0	65.0	65.0	65.0	65.0															
<i>New German Länder</i>	64.0	65.0	65.0	65.0	65.0															
Refinery gas	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Other petroleum products Germany						80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
<i>Old German Länder</i>	80.0	80.0	80.0	80.0	80.0															
<i>New German Länder</i>	78.0	78.0	78.0	78.0	78.0															
Lubricants	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Gases																				
Coking-plant and city gas Germany						40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
<i>Old German Länder</i>	40.0	40.0	40.0	40.0	40.0															
<i>New German Länder</i>	50.0	50.0	50.0	50.0	50.0															
Top gas, Old and new German Länder	264.0	264.0	264.0	264.0	264.0															
Blast-furnace and converter gas, Germany						255.8	257.9	257.8	257.5	257.4	257.5	257.7	257.5	257.6	257.5	257.7	257.5	257.7	257.8	257.5
Flammable gas New German Länder	49.0	49.0	49.0	49.0	49.0															
Other gases Germany														60.0	60.0	60.0	60.0	60.0	60.0	60.0
Natural gases																				
Natural gas Germany						56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0
<i>Old German Länder</i>	56.0	56.0	56.0	56.0	56.0															
<i>New German Länder</i>	55.0	55.0	55.0	55.0	55.0															
Petroleum gas	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0
Pit gas	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0

Fuel-based emission factors [t CO ₂ /TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Waste																				
Household waste / municipal waste	109.6	107.0	104.6	100.1	98.0	96.9	95.8	94.7	93.6	92.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5
Industrial waste <i>Germany</i>						71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Old German Länder ²⁾	73.9	73.9	74.0	74.1	74.3															
New German Länder ²⁾	74.9	74.8	74.7	74.6	74.6															
Special waste <i>Germany</i>						83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0
Special fuels ¹⁾																				
Used oil	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7
Recycled plastics						74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6
Recycled tyres	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
Bleaching clay	NO	NO	NO	NO	NO	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3
Commercial waste - plastic	NO	NO	NO	NO	NO	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1
Commercial waste - paper	NO	NO	NO	NO	NO	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9
Commercial waste - other	NO	NO	NO	NO	NO	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1
Commercial waste - packaging	NO	NO	NO	NO	NO	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9
Sewage sludge	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	95.1	95.1	95.1	95.1	95.1	95.1	95.1
Solvents (waste)	NO	NO	NO	NO	NO	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Oil sludge	NO	NO	NO	NO	NO	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Paper-industry residues	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2
Processed municipal waste	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8
Carpet waste	NO	NO	NO	NO	NO	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4
Textile waste	NO	NO	NO	NO	NO	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3

Fuel-based emission factors [t CO ₂ /TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Biomass fuels ³⁾																				
Spent liquors from pulp production	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Fibre/de-inking residues	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9
Waste wood, wood scraps (industry)	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1
Waste wood, wood scraps (commercial/institutional)	NO	NO	NO	NO	NO	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
Bark	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4
Animal meals and fats	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6
Animal fat	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	74.9	74.9	74.9	74.9	74.9	74.9	74.9	74.9	74.9
Firewood ⁴⁾	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4
Landfill gas, sewage-treatment gas, biogas ⁴⁾	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6
Bioethanol	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Biodiesel ⁴⁾	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8
Other factors [kg/t]																				
Flue-gas desulphurisation	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0

- 1) Designations of fuels as defined for the inventory data can diverge from other standards, and they are listed as such, and given EF as such, only in the inventory.
- 2) Annual change in the EF as a result of differences in shares for combustion systems and companies' own plants; for 1990-1994, listed separately in each case for old German Länder / new German Länder
- 3) Listed for selected fuels; calculated CO₂ emissions are reported only as memo items, and do not enter into the total inventory quantities; biomass fractions from special fuels (see above) are not listed separately, because their CO₂ EF are not differentiated.
- 4) Default values

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

Table 282: Emission factors for CO₂ as of 1990, as derived for emissions reporting: industrial processes

Industrial processes [kg CO ₂ / t (raw material or product)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2.A.1 Production of cement clinkers	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
2.A.2 Production of burnt lime	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00
2.A.2 Production of dolomite lime	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00
2.A.3 Use of limestone	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.A.4 Use of soda ash	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00
2.A.7 Production of masonry bricks	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10
2.A.7 Production of roof tiles	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60
2.A.7 Production of container glass	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00
2.A.7 Production of flat glass	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00
2.A.7 Production of household and table glassware	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
2.A.7 Production of special glass (mix)	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00
2.A.7 Production of glass fibre (mix)	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00
2.A.7 Production of rock wool (mix)	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00
2.A.7 Production of glass (mix not differentiated for new German Länder)	174.00	174.00	174.00	174.00	174.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B.1 Production of ammonia	1586.89	1557.89	1582.14	1581.70	1520.87	1550.09	1513.23	1509.35	1503.09	1535.57	1481.95	1468.98	1458.39	1411.58	1442.22	1389.32	1332.81	1326.16	1320.76	1277.17
2.B.4 Production of calcium carbide	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2.B.5 Coke burn-off in catalyst regeneration	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42
2.B.5 Production of carbon black	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196
2.B.5 Production of methanol	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00
2.C.1 Production of electric steel	8.50	8.00	7.50	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374
2.C.1 Production of oxygen steel; limestone input	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.C.2 Ferroalloys production	1500.00	1222.00	944.00	527.00	249.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
2.C.2 Ferroalloys production (new German Länder)	1500.00	1500.00	1500.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.3 Production of foundry aluminium	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00

C Confidential data

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

18.7 Analysis of CO₂ emissions from non-energy-related use of fuels

The great majority of the coal, oil and gas that Germany uses is used for energy-related purposes. The remainder of the coal, oil (about 20 % in 2007) and gas is used as feedstock for production processes. This consumption enters into the balance as "non-energy use" (NEU).

In the German Energy Balance, this consumption is listed separately, in line 43. The chemical industry is the leading user of fossil fuels for non-energy-related purposes. The German chemical sector uses such fuels in production of basic chemicals such as ammonia, ethylene und propylene, which are used, in additional production steps, to make such important products as fertilisers and plastics. Additional applications include production of graphite electrodes, asphalt for road construction and a range of waxes and lubricants.

Table 283 (see below) presents a comparison of a) the consumption listed in line 43 and b) reported emissions of CO₂ and NMVOC from use of fossil fuels in non-energy-related applications. Emissions from non-energy-related applications were correlated with the various relevant fuels in keeping with Table 1.3 from Volume 3 of IPCC-GL 2006 and in accordance with information provided by producers and experts. In some cases, we had to make our own estimates of the applicable correlation with individual fuels.

The comparison highlights a discrepancy between the carbon quantities reported in line 43 and the relevant emissions, especially in the case of mineral oils. In 2007, NMVOC and CO₂ emissions correlated with about 14 % of non-energy-related consumption; some 86 % of non-energy-related consumption is tied to indirect emissions.

To compare a) the carbon used in connection with the fuels and b) the resulting emissions, one must also take relevant products' entire life cycles into account. Such life cycles include production, use and disposal of products – and exports. In source category CRF 1A, Germany reports (inter alia) emissions from waste incineration for energy-related purposes. Many products are not disposed of in the same year in which they are produced. In some products, carbon can be bound up for considerable periods of time. In asphalt, for example, bitumen carbon can remain stored for especially long periods. Other products, such as plastics, are exported as tradeable goods. Waste is also exported to other countries. Such products, along with the carbon they contain, cannot be taken into account in the carbon balance for Germany considered in the present context. They are responsible for a significant discrepancy between the carbon quantities used, and those emitted, in non-energy-related consumption in Germany. The carbon quantities used in non-energy-related consumption are considerably greater than the carbon quantities that would correspond to the reported CO₂ and NMVOC emissions from non-energy-related use of fossil fuels.

To determine whether the quantities listed in the Energy Balance as "non-energy use" actually show up in the relevant feedstock quantities, the fossil-fuel carbon stored in relevant products was balanced. In the chemical industry, fossil fuels are used in crackers, reforming processes and production of synthetic gases. In crackers and reforming, the most important products resulting from such processes are ethylene, propylene, 1,3-butadiene, benzene, toluol and xylene; in production of synthetic gases, the most important such products are ammonia and methanol. The products produced in refineries include bitumen, lubricants and paraffins, waxes and vaseline. Bitumen is used in a range of applications, including road surfaces and bitumen sheeting for roofs. Lubricants are used in road vehicles and machines

(inter alia). For purposes of comparison with line 43, the produced quantities of the listed products were obtained from data of the Federal Statistical Office. Those data were then stoichiometrically converted into proportional CO₂ equivalents.

For methanol, ethylene, propylene, 1,3-butadiene, benzene, toluene and xylene, the carbon content was stoichiometrically converted, via the molar masses of the products and of CO₂, into CO₂ equivalents. Then, the pertinent CO₂ equivalent emissions were distributed among the three feedstocks used in Germany (naphta, LP gas and other mineral-oil products). The possible relevant distributions include distribution of emissions and products' carbon content among the various fuels involved. The example of ethylene (C₂H₄) is used to illustrate the manner in which the carbon is converted into CO₂:

$$\begin{aligned} M(\text{CO}_2) &= 44 \text{ g/mol} \\ M(\text{C}_2\text{H}_4) &= 28 \\ \text{CO}_2 \text{ equivalents} &= \text{AD} * 2 * 44 / 28. \end{aligned}$$

In the case of carbon black, the product is assumed to consist of pure carbon. That carbon was also converted into CO₂ equivalents, via the applicable stoichiometric relationship.

The production quantities of lubricants, waxes, paraffins, vaseline and other products were converted via the following values, taken from the monitoring guidelines used in emissions trading (Table 4, p. 33).

	EF	Lower net calorific value
	t CO ₂ /TJ	TJ/Gg
Bitumen	80,6	40,2
Paraffin wax	73,3	40,2
Lubricating oil	73,3	40,2

For 2007 in the Submission 2011,, the sum of the carbon from the pertinent emissions and of the carbon stored in products amounts to 103 % of the non-energy-related consumption given in line 43 of the Energy Balance. The total share for the chemical industry is about 75 %, and the total share for refinery products is about 24 %.

Table 283: Verification of completeness of reported CO₂ from non-energy use of fossil fuels

			Coal						Petroleum								Gas		
			Hard coal	Hard-coal coke	Other hard-coal products	Lignite (Braunkohle)	Other lignite products	Total solids	Raw benzene (naphtha)	Diesel fuel	Heating oil, light	Heating oil, heavy	Petrol coke	Liquid gas	Refinery gas	Other petroleum products	Total liquids	Natural gas	Total gas
Year	2007	Unit																	
A: Declared NEU (Energy Balance line 43)		TJ	1.661	1.833	2.780	392	10,082		466,479	1	42,761	154,925	7,903	55,442	23,369	150,279		87,221	
B: Carbon content		kg C/GJ	26,8	29,2	26,8	27,6	27,6		20,0	20,2	20,2	21,1	26,6	17,2	15,7	20,0		15,3	
C: Total supplied for feedstock/non-energy		Gg C	44,5	53,5	74,5	10,8	278,3	461,6	9.329,6	0,0	863,8	3.268,9	210,2	953,6	366,9	3.005,6	17.998,6	1.334,5	1.334,5
D: Total supplied for feedstock/non-energy		Gg CO ₂	163,2	196,3	273,2	39,7	1.020,3	1.692,6	34.208,5	0,1	3.167,2	11.986,0	770,8	3.496,5	1.345,3	11.020,5	65.994,8	4.893,1	4.893,1
E: Implied carbon fraction oxidised				3.90				0.45	1.00			0.87	0.02	1.00		1.85	1.04	1.06	1.06

	AD	EM	Gg CO ₂																
	Gg	Gg CO ₂																	
T: Total fossil IPPU CO₂ reported		7.773,1		765,1				765,1	34.206,3			10.418,3	17,5	3.497,5		20.350,1	68.489,7	5.183,4	5.183,4
2 Industrial processes																			
2.A: Mineral industry																			
2.B: Chemical industry		7.008							34.206			10.418	18	3.497		5.001	53.140	5.183	5.183
2.B.1: Ammonia production	3.266	4.331										2.887,3					2.887,3	1.443,7	1.443,7
CO ₂ for other uses	3.390											3.390,0					3.390,0		
2.B.5: Carbide production	C	18											17,5				17,5		
2.B.5: Other																			
Methanol CH ₃ OH	2.025	1.357										4.141,0					4.141,0		
Ethylene C ₂ H ₄	5.097								12.832,5					1.312,1		1.876,0	16.020,6		
Propylene C ₃ H ₆	3.492								8.790,8					898,8		1.285,2	10.974,8		
1,3-butadiene C ₄ H ₆	1.149								3.000,1					306,7		438,6	3.745,4		
Benzene C ₆ H ₆	2.214								6.003,0					613,8		877,6	7.494,4		
Toluene C ₇ H ₈	760								2.039,2					208,5		298,1	2.545,9		
Xylene C ₈ H ₁₀	579								1.540,6					157,5		225,2	1.923,3		
Carbon black	665	1.303																3.739,7	3.739,7
2.C: Metal industry		765		765,1				765,1											
2.C.1: Iron and steel production (1)	IE	IE																	
2.C.2: Production of ferroalloys	72	8		8				7,9											
2.C.3: Primary aluminium production	554	757		757				757,2											
2.C.5: Other																			
Lead production	NE	NE																	
Zinc production	NE	NE																	
2.D: Other production:																			
3. Solvent and other product use																			
3.A-D: Solvents (2)	IE	IE							IE										

			Coal						Petroleum									Natural gas	
Year	AD [Gg]	EM [Gg CO ₂]	Hard coal	Hard-coal coke	Other hard-coal products	Lignite (Braunkohle)	Other lignite products	Total solids	Raw benzene (naphtha)	Diesel fuel	Heating oil, light	Heating oil, heavy	Petrol coke	Liquid gas	Refinery gas	Other petroleum products	Total liquids	Natural gas	Total gas
EXCEPTIONS REPORTED ELSEWHERE																			
1.A FUEL COMBUSTION ACTIVITIES																15.349,4	15.349,4		
1.A.1.b: Petroleum refining																			
Lubricants	1.056															3.110,3	3.110,3		
Waxes, paraffins, vaseline, etc.	305															898,7	898,7		
Bitumen	3.500															11.340,4	11.340,4		
1.A.3 Lubricants in road transports (3)	IE	IE														IE			

- (1) Since coke inputs in the iron and steel industry are not included in the Energy Balance, the relevant CO₂ emissions are not included here.
- (2) Since over 90 % of solvents from basic chemicals are produced in steam crackers, it is assumed that carbon emitted from NMVOCs comes from products of such crackers.
- (3) Use of lubricants is already covered by the total quantity of produced lubricants.

19 ANNEX 3: OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES, INCLUDING KP-LULUCF ACTIVITIES

19.1 Other detailed methodological descriptions for the source category "Energy" (1)

19.1.1 *Revision of the activity data for stationary combustion systems of the new German Länder for the year 1990 and for subsequent years (1.A.1 and 1.A.2)*

That chapter has been deleted, in order to reduce the length of the present version. For those who wish to review it, it is provided in the NIR 2010.

19.1.2 *Energy Industries (1.A.1)*

19.1.2.1 Methodological aspects of determination of emission factors (Chapter 3.2.6.2)

This section of the Annex describes the main steps carried out in the research project RENTZ et al (2002) for determination of emission factors. (This description does not apply to the CO₂ emission factors whose determination is described in Annex 2 (Chapter 18.6).

Determination of emission factors requires detailed analysis of all operational facilities with regard to technologies used and design-specific emission behaviour. Three overarching source categories are formed: large combustion systems, combustion systems within the scope of application of the Technical Instructions on Air Quality Control (TA Luft) and gas turbines. Existing plants are classified in terms of emissions-relevant characteristics, and the pertinent emission factors are determined. These so-called "technology-specific" factors can then be aggregated in an adequate manner. This database also provides the basis for estimating future emissions (changes in the overall make-up of the entire group of facilities, in terms of percentage shares for various facility types). This procedure thus consists of the following steps:

1. Characterisation of the equipment-specific emissions behaviour of combustion systems.

In a first step, the combustion and emissions-reduction technologies used in Germany are briefly described, and the relevant emissions-determining factors are explained. On the basis of this characterisation, emission factors are derived for the various different relevant technologies, differentiated by size class and fuel type. The chosen classification is also oriented to applicable provisions under immissions-control law, an orientation that permits derived emission factors to be compared with limits applicable now or in the future.

2. Analysis of source-category structure

Emissions calculations must be carried out using emission factors that have the same references as the pertinent energy-input data. The latter (data) is broken down by source categories that are derived from the national Energy Balance – cf. Chapter 3.2 – and are not based on the combustion technologies used. The project has defined and analysed the following source categories: Public electricity and heat production (CRF 1.A.1a), Industrial power stations (CRF 1.A.1c for mining-sector power stations;

otherwise CRF 1.A.2), District-heating stations (CRF 1.A.1a), Refinery power stations (CRF 1.A.1b), Industrial combustion systems (CRF 1.A.1c and 1.A.2) and residential, institutional and commercial (small consumers) (CRF 1.A.4 and 1.A.5). In the analysis, the various technologies' contributions to total energy use must be determined. The most important data sources for this include the power-station database of the DFIU, relevant statistics, communications of industry associations (VGB, VDEW, VIK), operator information and technical publications. Furthermore, excerpts of emissions declarations from the year 1996, as provided by some Länder authorities, were also evaluated in the present context.

3. Aggregation of emission factors

On the basis of the percentage contributions for the various technologies – which were determined separately for the old and new Länder – the technology-specific emission factors were aggregated to form source-category-specific factors. Finally, factors for Germany as a whole were formed. The source-category-specific factors are subdivided in accordance with the categories "large combustion systems", "TA Luft combustion systems" and "gas turbines", as well as by fuel type. Aggregated emission factors are formed first for the reference year 1995.

4. Projections for 2000 and 2010

For description of continuing technological development, technology-specific emission factors are again determined. These are derived from characterisation of modern technologies. An increasing contribution of low-emissions technologies to total relevant activity, thus, can be represented by suitably changing the percentage shares for the technologies under consideration. Applicable immission-control laws are used as a framework for updating for the year 2000. It is assumed that the requirements of the amended TA Luft (Technical Instructions on Air Quality Control) and of the EU directive on large combustion systems will be met by the reference year 2010.

The above-described methods, beginning with characterisation of the emissions behaviour of relevant combustion technologies and gradually leading to aggregated factors at various regional and source-category-specific levels, make it possible to represent the required factors transparently.

The chosen methods for deriving emission factors for a given reference year are shown in Figure 65 below.

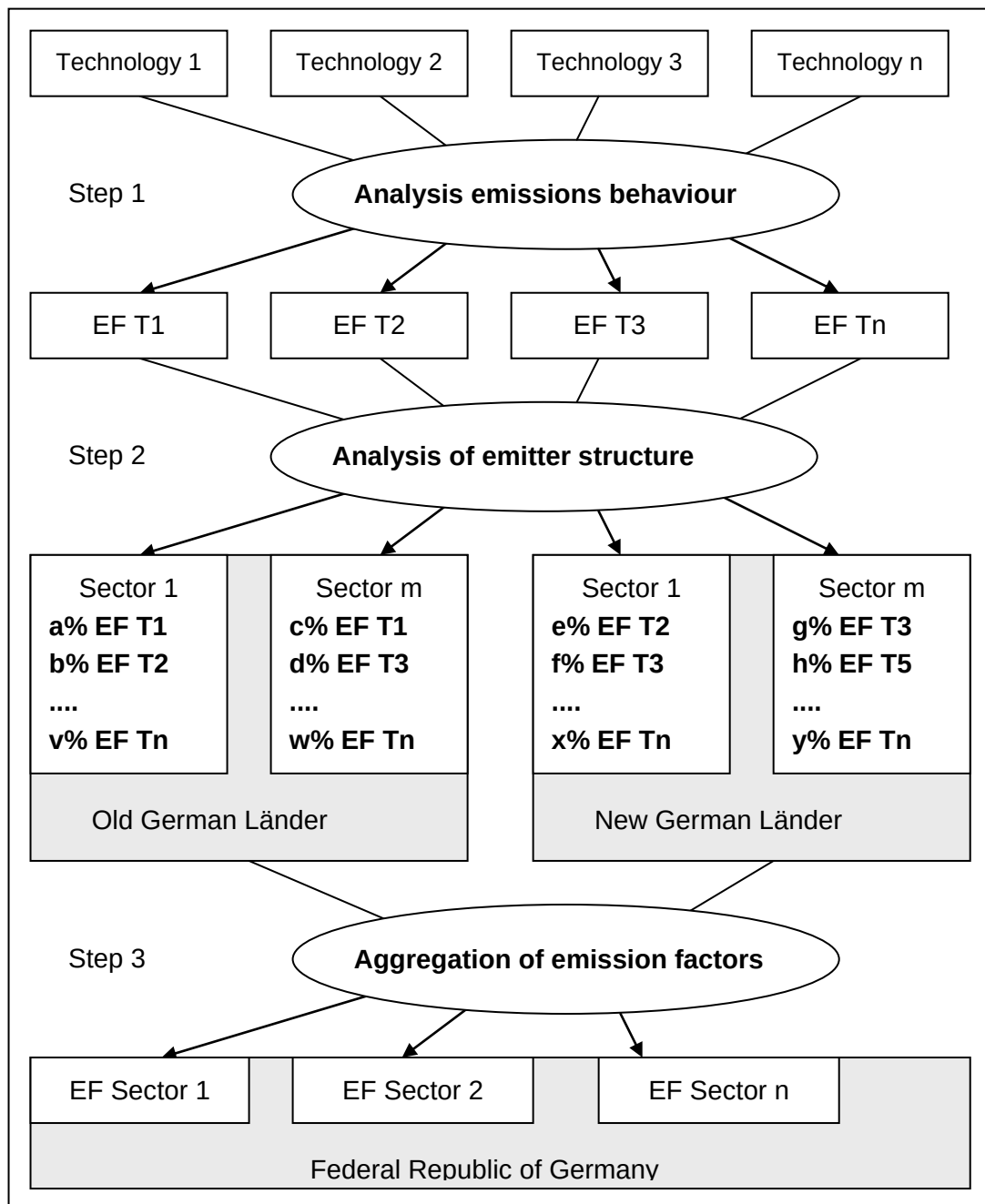


Figure 65: Methods for calculating emission factors

The origins and quality of the data are described in detail in the project report (RENTZ et al, 2002). A large part of the data comes from emissions declarations of the Länder Baden-Württemberg, Brandenburg, North Rhine – Westfalia and Thuringia for 1996. The annual pollutant loads listed therein are based, depending on the pollutant concerned, on measurements from continuous monitoring, on individual measurements or on calculation on the basis of physical laws, mass balances or emission factors. In the following, the emissions declarations of the state of Baden-Württemberg are used to show, by way of illustration, what data-determination methods tend to be used for the various types of combustion systems and substances in question. Such analysis makes it possible to classify the quality of the underlying data with regard to the derived technology-specific emission factors. At the same time, the description illustrates the data-evaluation procedure. Where a sufficient amount of data for a source category is available, the relevant value range is characterised via the

median and the percentile is characterised at 25 % and 75 %⁸⁵. This produces a robust estimate that, unlike characterisation via the mean value, is not distorted by extreme values. In general, percentiles at 5 % and 95 % are also listed, to describe the distribution of values. Similar percentile evaluations were also carried out for the emissions declarations of the other Federal Länder.

In the following, a distinction is made between measured data (either continuous measurements or individual measurements) and data based on calculations or emission factors. In evaluation, therefore, individual data items are first classified as either "measurements" (M) or "assumptions" (A). This general overview, in turn, is divided into the categories of large combustion systems, TA Luft combustion systems and gas turbines. These are then further subdivided, with regard to declaration obligations, into installations subject to abbreviated (K) or complete (V) declarations. For each of the three groups of installations, evaluation and derivation of emission factors is carried out, using the sample data from Baden-Württemberg and with classification by "measurements" and "assumptions".

Table 284 provides an overview of the installation types in question and lists the relevant numbers under the 4th BImSchV and the relevant type of declaration required.

Table 284: Installation types pursuant to Annex of 4th BImSchV (4th Ordinance on Execution of the Federal Immission Control Act)

Index	Large combustion systems (Großfeuerungsanlagen)		Type of declaration required
1 01 1	Power stations (plants)	≥ 50 MW for solid, liquid and gaseous fuels	V
1 02A 1	Combustion systems	≥ 50 MW for solid and liquid fuels	V
1 02B 1	Combustion systems	≥ 50 MW for gaseous fuels	V
Index	TA Luft installations		Type of declaration required
1 02A 2	Combustion systems	1 - < 50 MW solid and liquid fuels (except for heating oil EL)	V
1 02B 2	Combustion systems	5 - < 50 MW heating oil EL	K
1 02C 2	Combustion systems	10 - < 50 MW for natural gas	K
	Combustion systems	10 - < 50 MW except for natural gas	V
1 03 1	Combustion systems	> 1 MW, other fuels	V
Index	Gas turbine systems		Type of declaration required
1 05 1	Gas turbines	≥ 50 MW for natural gas	K
	Gas turbines	≥ 50 MW, except for natural gas	V
1 05 2	Gas turbines	< 50 MW for natural gas	K
	Gas turbines	< 50 MW, except for natural gas	V

In the analyses, emissions data is differentiated by combustion technologies. Table 285 provides an overview of this technology classification based on types. Categories 110 to 118 apply mainly to solid fuels, while 120 to 125 apply to liquid fuels and 130 to 132 apply to gaseous fuels.

⁸⁵ For the entire value range of a variable X, the sum-frequency distribution can be used to estimate what percentage of all units considered will have a maximal value of x. This value is termed a *quantile*: or, where percentage shares are used, as a *percentile*:). The best-known percentile that separates the lower half of all values from the upper half is the 50% percentile, the so-called *median*. The 25 and 75% percentiles cut off the upper and lower quarters of the distribution. They are thus also referred to as upper and lower *quartiles* or as the first and third quartile (with the median being a sort of second quartile).

Table 285: Classification of sources by type of combustion system

Technology	
Type	Meaning
110	Combustion systems for solid fuels / waste
111	Filled-shaft combustion systems
112	Combustion with throw feed
113	Combustion systems with pneumatic feed
114	Under-thrust combustion
115	Combustion with mechanically moved grids
116	Dust incineration with dry-ash ventilation
117	Dust incineration with wet-ash ventilation
118	Fluidised-bed combustion
120	Combustion systems for liquid fuels / waste
121	With evaporative burner
122	With pressure-atomising burner
123	With steam-atomising burner
124	With rotation-atomising burner
125	With air-atomising burner
130	Combustion systems for gaseous fuels / waste
131	With atmospheric gas burner
132	With gas-blower burner
141	Multiple-substance combustion systems
142	Mixed combustion
815	Gas turbines

19.1.2.2 Methane emission factor in the research project RENTZ et al, 2002

The following Table 286 summarises the emission factors shown in Tables 3, 4 and 5 of Annex E of the research project RENTZ et al (2002):

Table 286: Methane emission factors for combustion systems < 50 MW thermal output and for gas turbines, pursuant to RENTZ et al, 2002

Installation type	Fuel	Länder	CH ₄ EF [kg/TJ]
Combustion systems < 50 MW thermal output	Hard coal (Steinkohle)	ABL	3.4
		NBL	3.3
	Hard-coal coke	ABL/NBL	19
	Lignite (Braunkohle)	NBL, Lausatian district (Lausitz)	269
		NBL, Central German district (Mitteldeutschland)	184
	Heating oil EL	ABL	0.02
	Natural gas	ABL/NBL	0.02
Gas turbines	Heating oil EL	D	0.5
	Natural gas	D	2

ABL Old German Länder

NBL New German Länder

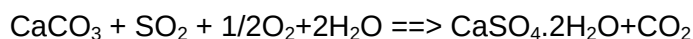
D Federal Republic of Germany as a whole

19.1.2.3 CO₂ emissions from flue-gas desulphurisation (CRF 1.A.1, Limestone balance)

In the framework of the research project "limestone balance" ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02), data for CO₂ emissions from flue-gas desulphurisation were determined for the source category Electricity and heat production in public power stations (cf. 4.2.3). Flue-gas desulphurisation systems have the task of converting sulphur dioxide in combustion gases, via chemical and physical processes, into substances that are less harmful.

Limestone is commonly used as a reagent in flue-gas desulphurisation. Desulphurisation systems are tailored to the applicable requirements under immissions-control law and to the economic value of the resulting residual substances (plaster). The predominant process used in electricity generating plants is limestone scrubbing. In terms of installed output, some 87 % of all power stations in Germany use this process (Rentz et al. 2002b).

Desulphurisation with CaCO_3 consists of several sub-reactions. For stoichiometric calculation of limestone inputs in the limestone-scrubbing process, the relevant chemical gross-reaction equation for the process is used (STRAUSS 1998):



This equation can be used to derive the limestone/plaster molar mass ratio. Such derivation shows that 581.39 kilograms of limestone are used per produced tonne of plaster. Plaster-production figures thus can be used to obtain the theoretically maximal limestone inputs for flue-gas desulphurisation in hard-coal-fired and lignite-fired power stations. The plaster-production figures do not indicate whether limestone or lime has been used, however. This problem was resolved with the help of statistics of the German Lime Association (BV Kalk) relative to sales of burnt and unburnt lime for the air-quality-control sector. Using the above reaction equation, the pertinent process-related CO_2 emissions can be determined from the mass relationship between CaCO_3 and CO_2 . The results of the calculation, which are shown in the following table, take account of figures for plaster production in all years between 1990 and 2007. To calculate plaster production for the years 2008 and 2009, we have used the 2007 plaster-production figure as a provisional input figure for the calculation. That, in turn, leads to slight recalculations for the years 2007 and 2008.

Table 287: CO_2 emissions from flue-gas desulphurisation in public power stations

in Gg	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 from flue-gas desulphurisation in public power stations	618	652	629	662	616	683	867	878	1005	966
in Gg	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 from flue-gas desulphurisation in public power stations	1,135	1,069	1,094	1,156	1,162	1,142	1,076	1,017	1,013	1,024

Source: Calculation on the basis of the "limestone balance" project (UBA 2006, FKZ 20541217/02); updated in 2008 (cf. NIR 2009)

In the inventory, these CO_2 emissions were assigned to emissions from use of solid fuels, because such use is the reason for operation of the flue-gas desulphurisation systems and for the systems' CO_2 emissions. Pursuant to expert estimates of the group carrying out the pertinent research, the uncertainty for limestone use and, thus, the uncertainty for related CO_2 emissions, is +/- 10 %.

19.1.3 Transport (1.A.3)

19.1.3.1 Transport – Civil aviation (1.A.3.a)

19.1.3.1.1 Derivation of additional emission factors (1.A.3.a)

Kerosene

Emissions of *sulphur dioxide* depend directly on the sulphur content of the relevant jet kerosene. That, in turn, is subject to regional and chronological fluctuations. The emission

factor used by Eurocontrol for sulphur dioxide, 0.84 kg SO₂/t jet kerosene, lies between the values used to date in the German inventory for the years 1990 to 1994 (1.08 to 1.03 kg SO₂/t jet kerosene) and the value used by the German inventory for subsequent years (0.4 kg SO₂/t jet kerosene). The figures given in IPCC 2006b, which, at 1 kg SO₂/t kerosene, are of an order similar to the old inventory values, are based on a sulphur content of 0.05 mass percentage. According to current information of the Fachausschuss für Mineralöl- und Brennstoff-Normung⁸⁶ (FAM; technical committee for petroleum and fuels standardisation), jet kerosene in Germany typically has a total sulphur content of about 0.01 mass percentage, i.e. one-fifth of the content given by the IPCC. The 2009 inventory report uses a sulphur-content figure of 0.021 mass percentage for jet kerosene, on the basis of measurements from the year 1998 (Döpelheuer 2002). It seems plausible that the emission factor would decrease over time as a result of improved procedures and reduced maximum permitted levels. Consequently, a linear reduction is included here between the framework years 1990 (1.08 g SO₂/kg kerosene), 1998 (0.4 g) and 2009 (0.2 g). In addition, it is assumed that all of the sulphur in the fuel is converted into sulphur dioxide. Because the emission factor depends directly and solely on the sulphur content of the jet kerosene, this emission factor is used for both flight phases.

For water vapour, the emission factor used by Eurocontrol (2004) is 1,230 g H₂O/kg jet kerosene. Corinair (2006) uses a somewhat higher figure, 1,237 g H₂O/kg jet kerosene. In the interest of limiting the number of emission-factor sources, the Corinair figure (2006) is used. Since this emission factor is solely fuel-specific, it is also applied to both flight phases, for both national and international air transports.

NO_x, CO and HC emissions are calculated with the help of emission factors taken from the results of the TREMOD calculations. Those results, in turn, are based on aircraft-type-specific and operational-state-specific emission factors taken largely from the EMEP-EEA database. For 2009, specially adapted emission factors had to be applied to some 40 % of all take-offs (a full 70% of total kilometres flown). The reason for this is that that share of take-offs involved aircraft types that could not be suitably classified for the present purposes, even with the help of aircraft types with similar technical data. Those emission factors were determined via emissions functions, in the context of regression calculations, that calculate the emission factor for each engine type as a function of take-off weight. The basis for those functions consisted of the emission factors for existing aircraft types (cf. in this regard IFEU and Öko-Institut 2010).

Ammonia emissions are calculated, for both flight phases, with an emission factor of 0.173 g/kg jet kerosene (UBA, 2009).

In each case, the *NM VOC* emission factors are obtained from the difference between the emission factor for hydrocarbons and that for methane.

The IPCC emission-factor database does not list any values for dust emissions from jet kerosene (Total Suspended Particulate matter (TSP); PM_{2.5}; PM₁₀). For this reason, the emission factors for *dust* (TSP) are taken from *Corinair 2006*. Table 8.2 in that source lists differentiated values for the flight phases of an average fleet: For national flights, 0.7 kg TSP/LTO and 0.2 kg TSP/t jet kerosene; for international flights, 0.15 kg TSP/LTO and 0.2 kg TSP/t kerosene. According to that table, jet-kerosene consumption per LTO cycle of

⁸⁶

Personal e-mail communication with Dr. Feuerhelm, FAM Hamburg, 9 June 2009

825 kg for national flights, and 1,617 kg for international flights, is assumed. Those values are used to determine the emission factors for the LTO phase.

Avgas

In the *IPCC Guidelines* (2006a, page 3-64), the emission factors for *nitrous oxide* are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here – along with the forecasts for jet-kerosene use in cruise phases of national air transports (cruise phase in 2008).

As to fuel properties, there are no fundamental differences between avgas and automobile petrol⁸⁷. Consequently, values for specific SO₂ emissions from automobile petrol may be used for avgas. Pursuant to the Fachausschuss für Mineralöl- und Brennstoff-Normung (FAM; technical committee for petroleum and fuels standardisation), the maximum permitted level for total sulphur content in petrol-station fuel is 10 mg/kg, or 0.001 mass percentage, which is one-tenth of the figure given for jet kerosene. As a result, the emission factor used for SO₂ from jet kerosene has been reduced by 90 %.

Different types of avgas, with different levels of *lead*, are used, and the usage percentages for the different types are not available. In calculation of lead emissions, the value determined for the most common type, AvGas 100 LL (Low Lead), 0.56 g/l, is used. That value is somewhat lower than the value proposed in the Corinair Guidebook 2007, 0.6 g/l. Via an average fuel density of 0.75 kg/l, that emissions value is converted to an emission factor of about 0.75 g lead / kg avgas.

The emission factor for *dust* (Total Suspended Particulate Matter – TSP) is obtained from the lead content of AvGas 100 LL, via multiplication by a factor of 1.6 (for EF, cf. Table 288 below). That value has been taken from the TREMOD model, which is used for calculation of emissions from road transports.

As to emission factors for NMVOC, pertinent values are given in the *Revised IPCC Guidelines 1996* (pages I 42 and 40); those values are used here.

The other emission factors are not available as special values for average small aircraft. For this reason, they are assumed to be the same as the relevant jet-kerosene emission factors (national, cruise).

Table 288: Emission factors for avgas (1990-2009)

Gas	EF in [g/kg]	Remarks regarding the source or calculation
CO ₂	3,018.00	from IPCC Guidelines 2006, Table 3.6.4
CH ₄	0.36	same as EF kerosene, LTO/national/2009
N ₂ O	0.10	same as EF kerosene, cruise/national/2009
SO ₂	0.02	equivalent to 1/10 of EF kerosene, cruise/national/2009
H ₂ O	1,253.00	same as EF kerosene, cruise/national/2009
NO _x	12.51	same as EF kerosene, cruise/national/2009
HC	8.12	obtained via addition of EF for NMVOC and CH ₄
NMVOC	13.06	from Revised IPCC Guidelines 1996, p. I.42
CO	642.00	from Revised IPCC Guidelines 1996, p. I.40
TSP	1.18	calculated from lead content of AvGas 100 LL
Pb	0.75	calculated from max. lead content of AvGas 100 L

Source: Öko-Institut (2009)

⁸⁷ E-mail communications with Mr Winkler of the Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry, 8 June 2009

Table 289: Overview of emission factors used in the source category Transport – civil aviation (1.A.3.a)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1.A.3.a - Overarching																				
CO₂	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150
SO₂	1.08	1.00	0.91	0.83	0.74	0.66	0.57	0.49	0.40	0.38	0.36	0.35	0.33	0.31	0.29	0.27	0.25	0.24	0.24	0.22
National, LTO																				
CH₄	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
N₂O	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NO_x	11.13	11.44	11.46	11.17	11.39	11.41	11.35	11.24	11.19	11.07	11.13	11.10	10.96	10.76	10.64	10.39	10.25	10.25	10.45	10.53
NM VOC	2.7	2.0	1.6	1.2	1.2	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.5	1.4	1.5	1.5	1.6	1.7	1.8	1.8
CO	15.69	14.86	14.46	14.07	14.83	14.89	14.83	14.71	15.40	15.33	15.28	15.40	15.45	15.32	15.48	15.65	15.85	16.01	15.91	16.00
National, Cruise																				
CH₄	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N₂O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NO_x	12.58	13.43	13.50	12.86	13.25	13.33	13.40	13.35	13.20	12.99	13.14	13.12	13.06	12.72	12.67	12.45	12.45	12.52	12.75	12.97
NM VOC	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
CO	2.86	2.98	3.06	3.23	2.96	3.06	2.97	2.96	2.86	2.96	2.90	2.82	2.81	2.85	2.78	2.62	2.52	2.41	2.37	2.32
International, LTO																				
CH₄	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
N₂O	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
NO_x	12.59	12.63	12.79	12.82	13.05	13.05	12.79	12.67	12.69	12.63	12.57	12.49	12.38	12.33	12.28	12.32	12.34	12.35	12.40	12.53
NM VOC	4.5	4.1	3.6	3.2	3.2	3.2	2.6	2.3	2.7	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.3	2.4	2.4	2.4
CO	16.39	15.55	14.89	14.26	14.67	14.98	13.87	13.67	14.24	14.29	14.50	14.61	14.55	14.67	14.72	14.87	14.95	15.14	15.05	15.09
International, Cruise																				
CH₄	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N₂O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NO_x	14.91	14.63	14.41	14.31	14.35	14.61	14.05	13.77	13.97	13.86	13.81	13.76	13.63	13.55	13.51	13.54	13.58	13.58	13.58	13.60
NM VOC	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
CO	1.27	1.26	1.24	1.25	1.23	1.22	1.24	1.25	1.26	1.26	1.27	1.26	1.25	1.26	1.26	1.25	1.26	1.26	1.26	1.27

19.1.3.1.2 Detailed overview of the uncertainties underlying the pertinent activity data and emission factors (1.A.3.a)

Table 290: Übersicht der zu berücksichtigten Teilunsicherheiten der Aktivitätsraten und Emissionsfaktoren

Individual components		Partial uncertainties		AD (kerosene & avgas)		SF (LTO/ cruise)		AD (kerosene) LTO and cruise		EM (CO ₂) LTO and cruise		EM (CH ₄) LTO and cruise		EM (N ₂ O) LTO and cruise		EM (SO ₂) LTO and cruise		EM (H ₂ O) LTO and cruise		Remaining EM LTO+cruise		Source / reason for assumptions
		[%]		Total	n / i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	
AD of AGEB and BAFA		-5	5	x	x																	Öko-Institut / DIW 2007. Here, the higher uncertainties of the Energy Balance are used. The uncertainties for the BAFA data are +3, -1% (conservatively estimated, using the approach for the uncertainties of mineral-oil statistics, which are based on BAFA data.)
Split factor SF n < i		-10	10		x																	From 1990-2002, calculations pursuant to Tremod were used; as of 2003, calculations pursuant to Eurocontrol are used. The value here is a mixed value for the entire time series.
AD (kerosene)	n & i	-11	11					x	x													Calculated
Data of the Federal Statistical Office relative to aircraft movements	n	-0.1	0.1			x																Aviation statistics are based on the Transport statistics act (Verkehrsstatistikgesetz - VerStatG). The data specified by Arts. 12, 13 VerStatG are recorded. Pursuant to that act, all civil aviation craft, including aircraft, helicopters, airships, motorised gliders, sailplanes and manned balloons, are to be included in relevant surveys, as long as airports/airfields in Germany are involved.
	i	-0.1	0.1				x															
Real-distance addition	n & i	-3	3			x	x															The data of the Federal Statistical Office are oriented to great-circle distances. A detour factor for cruise flight has been used, as a means of estimating the distances actually flown (cf. IFEU and Öko-Institut 2010).
Allocation of consumption values for kerosene to aircraft types	n	-5	5			x																Aircraft types pursuant to the Federal Statistical Office are assigned emission factors from the EMEP-EEA database. There are four different quality levels for such assignment: a) direct, b) via similar types, c) via regression functions depending on take-off weight, and d) lump-sum EF.
	i	-5	5				x															
SF (LTO / cruise)	n	-6	6					x														Calculated
	i	-6	6						x													Calculated
AD (kerosene) LTO and cruise	n	-13	13							x		x		x		x		x		x		Calculated
	i	-13	13								x		x		x		x		x		x	Calculated
Emission factors (EF)	CO ₂	5	5							x	x											IPCC 2006, p.3.69; low uncertainty, since the EF depends only on the C content of the fuel.
	CH ₄	-57	100									x	x									IPCC 2006, p.3.69; depends on technology and is thus subject to large uncertainty in combination via the Tier 1 approach
	N ₂ O	-70	150											x	x							The emission factor depends only on fuel characteristics (sulphur content).
	SO ₂	-10	10													x	x					The emission factor depends only on fuel characteristics. Low values, ranging from – 4.9 to 1.6, given in Eurocontrol 2004, p.49.
	H ₂ O	-5	5															x	x			
Remaining EF	n & i	-10	10																	x		Assumption – for NO _x , HC and CO, an average EF is calculated via TREMOD, on the basis of the EF for individual aircraft types
Total uncertainty, above				+5	+11	+6	+6	+13	+13	+14	+14	+58	+58	+71	+71	+16	+16	+14	+14	+16	+16	
Total uncertainty, below				-5	-11	+6	-6	-13	-13	-14	-14	-101	-101	-150	-150	-16	-16	-14	-14	-16	-16	

n = national share; i = international share

Source: Öko-Institut (2009)

19.1.3.2 Derivation of activity data for road transport (1.A.3.b)

19.1.3.2.1 Harmonisation with the Energy Balance

The basis for CSE data collection for the road-transport sector consists of energy consumption data provided by the Working Group on Energy Balances (AGEB). For each year, the sum of the activity data for the various individual structural elements must correspond to the Energy Balance data, in TJ. The relevant basic Energy Balance data are shown in Table 291 below.

Table 291: Energy inputs in road transports, 1990-2009

Year	Petrol	Diesel fuel	Biodiesel	Bioethanol	LP gas	Natural gas	Petroleum
Energy inputs pursuant to Energy Balances 1990-2006 (last revision: 10/2009), in TJ							
1990	1,330,479	735,920	0	0	138	0	0
1991	1,332,285	785,174	0	0	184	0	0
1992	1,344,129	853,502	0	0	115	0	0
1993	1,350,617	907,787	0	0	100	0	473
1994	1,276,637	932,060	0	0	229	0	559
1995	1,299,982	964,013	1,504	0	184	0	610
1996	1,299,879	964,580	2,046	0	184	0	638
1997	1,297,487	979,586	3,652	0	138	0	357
1998	1,300,463	1,022,794	4,081	0	115	0	637
1999	1,300,602	1,097,036	5,370	0	106	0	637
2000	1,237,055	1,108,105	12,276	0	94	0	414
2001	1,199,318	1,097,416	16,740	0	569	0	471
2002	1,166,381	1,105,842	20,460	0	607	0	472
2003	1,108,989	1,078,352	29,948	0	694	0	0
2004	1,072,720	1,110,931	38,795	1,155	1,887	0	0
2005	992,377	1,077,173	71,725	6,884	2,357	2,843	0
2006	930,834	1,081,161	130,006	13,548	4,605	5,211	0
2007	892,982	1,078,362	143,461	12,182	8,942	4,089	0
2008	854,145	1,107,102	109,595	16,547	15,652	4,882	0
Provisional figures pursuant to "Mineralölzahlen 2009" (fossil; "2009 Mineral-Oil Statistics") and Amtliche Mineralöl-daten 12/2008 (bio; "Official Mineral-Oil Data 12/2008")							
2009	827,898	1,126,099	90,128	23,889	19,020	5,546	0

Sources: Evaluation tables of the Energy Balances, „Mineralöl-Zahlen 2009“ ("2009 Petroleum Data") of the Association of the German Petroleum Industry (MWV) (MWV, 2010) and „Amtliche Mineralöl-daten“ ("Official Petroleum Data").

The Energy Balance is also used to model transport-quantity structures in TREMOD. For example, the German Economic Institute (DIW) carries out a fuel-consumption calculation in order to derive total mileage travelled (DIW, 2002). Some of the results of the calculation, for automobile transports, are entered into TREMOD. The DIW uses a fuel-consumption calculation in order to determine total domestic mileage; TREMOD uses some other sources and assumptions to estimate total domestic mileage – especially for goods transports (cf. the detailed description in IFEU, 2002). This estimate also takes the basic figures of the Energy Balance into account.

On the other hand, due to the many dependencies and uncertainties in the model, and to the basic data that must be taken into account, no feasible means is available for comparing

mileage and energy consumption, for each year and each vehicle layer, in such a manner that the results yield the Energy Balance sum and the mileage and average energy consumption figures in the time series are plausible. For this reason, the TREMOD results for the energy consumption are corrected, at the end of the process, in such a manner that the total for each reference year corresponds to the relevant figure in the Energy Balance.

Since TREMOD calculates energy consumption in tonnes, the results first have to be converted into TJ. For this purpose the net calorific values of the Working Group on Energy Balances (AGEB) are used (cf. Table 292).

Table 292: Net calorific values for petrol and diesel fuel

Year	Petrol	Diesel fuel
1990-1992	43,543 MJ/kg	42,704 MJ/kg
since 1993	43,543 MJ/kg	42,960 MJ/kg

Source: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)

The correction factors are derived in TREMOD separately for the various vehicle categories, as follows:

- Firstly, a correction factor for petrol is derived from the calculated petrol consumption for all vehicle categories and from petrol sales pursuant to the Energy Balance.
- The correction factor for petrol is then also used to bring fuel consumption of vehicles with diesel engines, among automobiles and other vehicles ≤ 3.5 t (light duty vehicles (LNF), and of motor homes and motorcycles (MZR)), in line with the Energy Balance.
- The difference between the corrected diesel-fuel consumption of automobiles and of other vehicles ≤ 3.5 t and the Energy Balance is then allocated to heavy duty vehicles and busses.
- The correction factor for heavy duty vehicles and busses is then calculated from their energy consumption, as calculated in accordance with the domestic principle, and the pertinent difference, as calculated for this group, from the Energy Balance.

Table 293 below summarises the correction factors used.

Table 293: Correction factors for harmonisation with the Energy Balance

Year	Land (state)	Petrol (including bioethanol)	Diesel fuel (including biodiesel)	
		Auto- mobiles, light duty vehicles, motorcycles	Automobiles, light duty vehicles	Heavy duty vehicles, busses
1990	ABL	1.016	1.016	1.147
1990	NBL	1.024	1.024	1.588
1991	ABL	1.017	1.017	1.102
1991	NBL	1.036	1.036	1.097
1992	ABL	1.025	1.025	1.176
1992	NBL	0.989	0.989	1.253
1993	ABL	1.029	1.029	1.282
1993	NBL	0.974	0.974	1.186
1994	ABL	0.971	0.971	1.177
1994	NBL	0.971	0.971	1.177
1995	D	0.984	0.984	1.200
1996	D	0.988	0.988	1.179
1997	D	0.990	0.990	1.179
1998	D	0.988	0.988	1.242
1999	D	0.996	0.996	1.303
2000	D	0.971	0.971	1.333
2001	D	0.961	0.961	1.233
2002	D	0.959	0.959	1.190
2003	D	0.950	0.950	1.126
2004	D	0.960	0.960	1.067
2005	D	0.951	0.951	1.052
2006	D	0.932	0.932	1.085
2007	D	0.926	0.926	1.025
2008	D	0.927	0.927	0.996
2009	D	0.928	0.928	1.047

Remark: 1994 correction factors for old German Länder (ABL) and new German Länder (NBL) as for Germany (D) as a whole

19.1.3.2.2 Allocation of biofuels, petroleum, natural gas and LP gas to the structural elements

For the transport sector, the Energy Balance lists data for biofuels, petroleum, natural gas and LP gas. For purposes of importing into the CSE, the results for these fuels are derived as follows:

- Biodiesel is allocated to all structural elements with diesel engines, in keeping with their percentage shares of consumption of conventional diesel fuel.
- Bioethanol is allocated to all structural elements with petrol engines, in keeping with their percentage shares of consumption of conventional petrol.
- Petroleum is allocated to busses on roads outside of municipalities – and, thus, to the structural elements SV BUS KOAO and SV BUS MTAO – in keeping with their percentage shares of consumption of conventional diesel fuel
- LP gas is allocated to conventional automobiles, with petrol engines, on municipal roads (structural element SV PKWO KOIO).

19.1.3.2.3 Activity data for evaporation

The activity data for evaporation emissions is set as total petrol consumption, on municipal roads, pursuant to TREMOD; the corresponding figure for mopeds is the total consumption. The values corrected to the Energy Balance are used.

19.1.3.3 Derivation of emission factors

19.1.3.3.1 Emission factors from TREMOD

In the CSE, emission factors for the "engines" ("Antrieb") category are listed in kg/TJ, while those for the "evaporation" category are given in kg/t. For the substances "petrol" and "diesel fuel", these values can be derived from TREMOD for all structural elements. To that end, emissions (in tonnes) and energy consumption (in TJ; converted from the results "energy consumption in t", using the net calorific values pursuant to Table 292) are derived from the TREMOD results and allocated to the relevant structural elements. The emission factor for each structural element then results as the quotient produced by dividing emissions, in tonnes per structural element, by the energy consumption, per structural element, in TJ. A similar procedure is used to obtain the emission factors for evaporation (evaporation emissions, in kg / consumption on municipal roads, in t).

For purposes of this derivation, TREMOD results without correction to the Energy Balance are used, since such correction is already contained in the activity data for the CSE. Use of the corrected values (emissions and energy consumption) leads to the same results, however, since the correction factor cancels out in calculation of mean emission factors (emissions corrected / energy corrected = emissions uncorrected / energy uncorrected).

19.1.3.3.2 Emission factors for biodiesel, bioethanol, petroleum and LP gas

For all structural elements, the emission factors for biodiesel and petroleum are set at the same values as those for conventional diesel fuel. The emission factors for bioethanol are set at the same values as those for conventional petrol.

Exceptions:

- The CO₂ emission factor for biodiesel is set to 70.8 t/TJ;
- The SO₂ emission factor for petroleum is set to 24 kg/TJ for those years in which diesel fuel has a higher value. In all other years, the lower value for diesel fuel is used.

The emission factors for automobiles that run on LP gas are set as follows, in keeping with the Federal Environment Agency's specifications:

Table 294: Emission factors for automobiles that run on LP gas

Gas	Vehicle	Structural element	EB line	Units	1995-2007
CH ₄	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	3
CO	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	350
CO ₂	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	65,000.00
N ₂ O	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	1.7
NH ₃	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	0.5
NM VOC	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	157
NO _x	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	975
SO ₂	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	1.7

19.1.3.4 Derivation of data for western and eastern Germany, 1994

TREMOT distinguishes between old and new German Länder only until 1993. Since the CSE also requires such differentiation for 1994, a relevant breakdown must be made using simplifying assumptions. The framework conditions include:

- The sum total of activity data for engines (Antrieb) must correspond to the relevant Energy Balance values (in each case, for old and new German Länder).
- In the overall result, emissions resulting from linking activity data with emission factors must correspond to the TREMOD results for Germany.
- With these framework conditions, a relevant breakdown is possible only under the following assumptions:
- The emission factors for old and new German Länder are set, for all structural elements, to the relevant values for all of Germany in 1994.
- The structural elements' percentage shares of the activity data, for each fuel, are considered to be the same in each case for the old and new German Länder, and they are the same as the relevant values for all of Germany in 1994.

With these assumptions, the aforementioned conditions are fulfilled. A third condition is not fulfilled, however: the plausibility of emissions results in the time series, in each case, for the old/new German Länder.

19.2 Other detailed methodological descriptions for the source category "industrial processes" (2)

19.2.1 Mineral products (2.A)

19.2.2 Chemical industry (2.B)

19.2.3 Metal production (2.C)

19.2.4 Other production (2.D)

19.2.4.1 Pulp and paper (2.D.1)

The fibre for paper production is produced, via chemical or mechanical processes, either from fresh fibre or from processed recycled paper. A distinction is made between integrated and non-integrated pulp and paper mills. Non-integrated pulp mills (that produce pulp for the market) solely produce pulp for sale on the open market. On the other hand, integrated mills produce both pulp and paper, at the same sites. A paper mill can either produce paper from fibre material produced at other locations or be integrated within complete pulping processes set up at one site.

Sulphate pulp mills normally operate in both integrated and non-integrated modes, whereas sulphite pulp mills are normally only integrated – i.e. part of paper-production chains. In most cases, mechanical pulping and used-paper processing are a fixed part of the paper-production process; in a few cases, such processes are not so integrated, i.e. are carried out separately.

19.2.4.1.1 Fibre-production processes

Sulphate process

The sulphate process is the world's most common pulping process, since it yields higher pulp strengths and can be used with all types of wood. In the two German plants, carbonate is extracted from the circulating lye via bonding with calcium (causticising) and then, in a separate lime oven, is burned to burnt lime, a process that releases CO₂. The burnt lime is then reused for causticising. Pursuant to the *IPCC Good Practice Guidelines*, CO₂ released from CaCO₃ is assigned an emission factor of "0", since all of its carbon comes from pulped wood. Calcium loss from the cycle is compensated for solely via addition of burnt lime and thus, for the present purposes, also does not lead to report-relevant CO₂ emissions (the CO₂ released in production of burnt lime is already included in the figures for the lime industry (CRF 2.A.2)).

This process also produces atmospheric emissions in lye recovery (boilers), in bark combustion, from lime ovens, in wood-chip storage, in pulp digestion, in pulp washing, in bleaching, in bleach-chemical processing, in evaporation, in sorting and washing, in processing of circulating water and in operation of various types of tanks. Such emissions include fugitive emissions that occur at various processing points – primarily in lye-recovery boilers, lime ovens and auxiliary boilers. The main components of emissions include nitrogen oxides, sulphur-containing compounds, such as sulphur dioxide, and foul-smelling reduced sulphur compounds.

The two German sulphate-pulping plants are fitted with a system for post-incineration of foul-smelling sulphur compounds and with systems for NO_x-reduced combustion in lye-recovery boilers (>20 % NO_x reduction, as reported by the German Pulp and Paper Association (VDP), September 2004).

No other types of emissions-reduction equipment are yet being used in Germany:

- *Scrubbers* downstream from recovery boilers (>85 % SO₂ reduction)
- SNCR equipment for NO_x reduction downstream from the auxiliary boiler (>30 % NO_x reduction)
- SNCR equipment for NO_x reduction downstream from the recovery boiler (>30 % NO_x reduction)
- NO_x-reduction systems for combustion in auxiliary boilers (>20 % NO_x reduction)

Sulphite process

Sulphite pulp is produced in 4 of 6 systems in Germany. In such plants, pulping is carried out with various chemicals. The sulphate process and the sulphite process have numerous similarities, including similarities with regard to possibilities for using various internal and external measures to reduce emissions. From the standpoint of environmental protection, the main differences between the two pulp-production processes have to do with chemical aspects of the boiling process, with aspects of preparation and post-processing of chemicals

and with bleaching intensity – bleaching in sulphite plants is less intensive, since sulphite pulp is whiter than sulphate pulp.

Atmospheric emissions occur especially in lye recovery (boilers) and in bark combustion. Waste-gas emissions with less-concentrated SO₂ are released in washing and sorting processes, and they are released by ventilation shafts of evaporators and by various tanks. Such emissions escape – in part, as fugitive emissions – at various points of the process. They consist primarily of sulphur dioxide, nitrogen oxides and dust.

A number of measures are available for reducing consumption of live steam and electrical energy and for increasing plant-internal generation of steam and electricity. Sulphite pulp mills can generate their own heat and electricity by using the thermal energy in concentrated lye, bark and waste wood. Integrated plants require additional amounts of steam and electricity, however; these additional amounts can be generated either in on-site facilities or at off-site locations. Integrated sulphite pulp and paper mills consume 18 - 24 GJ of process heat, and 1.2 - 1.5 MWh of electrical energy, per tonne of pulp.

All four sulphite pulping plants in Germany are operated with SO₂ scrubbers fitted downstream from recovery boilers (>98 % SO₂ reduction). One plant is fitted with equipment for NO_x-reduced combustion in recovery and auxiliary boilers (total of >40 % NO_x reduction).

No other types of emissions-reduction equipment are yet being used in Germany:

- SNCR equipment for NO_x reduction downstream from the auxiliary boiler (>30 % NO_x reduction)
- SNCR equipment for NO_x reduction downstream from the recovery boiler (>30 % NO_x reduction)

Wood pulp

Wood pulp is produced in 9 plants in Germany. In mechanical pulping, wood fibres are separated from each other via mechanical energy applied to the wood matrix. The process is designed to conserve most of the lignin in the wood, in order to maximise yields while ensuring that the pulp has adequate strength and whiteness. Two main processes are differentiated:

- The wood-grinding process, in which pieces of wood are wettened and pressed against a rotating grinder, and
- The *refiner* process, in which wood chips are broken down into fibres in disk refiners.

Wood-pulp properties can be influenced by increasing the process temperature and, in the case of the *refiner* process, by chemical pre-treatment of the wood chips. The pulping process in which wood is chemically pre-softened and then broken down into fibres, under pressure, is known as *chemical-thermal-mechanical pulping* (CTMP).

In most cases, the waste-gas emissions consist of emissions from heat and energy generation in auxiliary boilers and of emissions of volatile organic carbon (VOC). VOC emissions occur in storage of wood chips, and in removal of air from containers, including containers for washing wood chips. They also occur in connection with condensates that are produced in recovery of steam from *refiners* and contaminated with volatile wood components. Some of these emissions are released as fugitive emissions, from various parts of mills.

The best available technologies for reducing waste-gas emissions include effective recovery of heat from refineries and reduction of VOC emissions from contaminated steam. Along with VOC emissions, mechanical pulping produces waste-gas emissions from on-site energy generation (i.e. non-process-related emissions). Heat and electricity are generated through combustion of various fossil fuels and wood residues (the latter are a renewable resource). The best available technologies for auxiliary boilers are described below.

Recycled fibre

In general, processes that use recycled fibres (processes for processing used paper) can be divided into two main categories:

- Processes that use solely mechanical cleaning, i.e. processes that use no de-inking. Such processes are used for production of test liners, fluting, carton and cardboard;
- Processes that use mechanical and chemical technologies, i.e. that include de-inking. Such processes are used for production of newsprint, *tissue*, printing and copier paper, magazine papers (SC/LWC) and for some types of carton and commercial DIP (de-inked recycled paper).

The raw materials for paper production from recycled fibre include recycled paper (main component), water, chemical additives and energy in the form of steam and electricity. Waste-gas emissions occur primarily in energy generation through fossil-fuel combustion, in power stations.

Waste-gas emissions from mills that process recycled paper occur primarily in systems for heat production; in some cases, they are also produced by combined heat/power generation (CHP) systems. For this reason, energy efficiency is closely linked to reductions of waste-gas emissions. The energy-generation systems in such mills normally use standard boilers, and thus they may be considered truly similar to all other such power plants. The following measures are considered the best available techniques for reducing energy consumption and emissions into the atmosphere: heat-power cogeneration, modernisation of existing boilers and retrofits (in connection with replacement investments) with more energy-efficient systems.

Energy-efficient mills for processing recycled paper consume process heat and electrical energy on the following scales:

- Integrated mills that process recycled paper, without de-inking (for example, for production of test liners and fluting):
6 – 6.5 GJ/t process heat and
0.7 – 0.8 MWh/t electrical energy;
- Integrated mills for tissue production, with DIP systems:
7 - 12 GJ/t process heat and
1.2– 1.4 MWh/t electrical energy;
- Integrated mills for production of newsprint, and integrated mills for production of printing and writing paper, and including DIP systems:
4 – 6.5 GJ/t process heat and
1 – 1.5 MWh/t electrical energy.

19.2.4.1.2 Paper and carton production

Paper is made from fibre materials, water and chemical additives. The entire paper-making process consumes large amounts of energy. Electricity is required primarily for operation of various motors and for grinding of fibres. Process heat is used primarily for heating water, other liquids and air, for evaporating water in dry areas of paper machines and for converting steam into electrical energy (with heat/power cogeneration). Large amounts of water are required as process water and for cooling. Various additives are used in paper production, as process aids and to enhance product properties (paper additives).

Most of the waste-gas emissions produced by non-integrated paper mills are produced by steam-production and energy-generation systems. The boilers used in such systems are standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner as other auxiliary boilers of the same capacity (see below).

Energy-efficient, non-integrated paper mills consume heat and energy on the following scale:

- Non-integrated mills for production of uncoated fine paper consume process heat at a rate of 7 – 7.5 GJ/t and energy at a rate of 0.6 – 0.7 MWh/t;
- Non-integrated mills for production of coated fine paper consume process heat at a rate of 7 – 8 GJ/t and energy at a rate of 0.7 – 0.9 MWh/t;
- Non-integrated mills for production of tissue from fresh fibre consume process heat at a rate of 5.5 – 7.5 GJ/t and electrical energy at a rate of 0.6 – 1.1 MWh/t.

Auxiliary boilers

In considering waste-gas emissions from auxiliary boilers, one must take account of the actual energy balance of the pulp or paper mill concerned, the nature of the fuels that are supplied to the facility and any use of biomass fuels such as bark and waste wood. Pulp and paper mills that produce fibre materials from primary fibres normally use bark-fired boilers. Non-integrated paper mills, and mills that process recycled paper, generate waste-gas emissions primarily via their steam-production and/or energy-generation systems. Such systems normally consist of standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner in which all other systems of the same capacity are operated. The technologies involved include:

- Heat/power cogeneration, where the prevailing heat/power ratio permits;
- Use of renewable fuels, such as wood and any waste wood that is produced, in order to reduce emissions of fossil CO₂;
- Reduction of NO_x emissions from auxiliary boilers, via control of combustion conditions and installation of burners with low NO_x emissions;
- Reduction of SO₂ emissions through use of bark, gas and low-sulphur fuels, and waste-gas scrubbing to remove sulphur compounds;
- Use of effective electrical filters (or tube filters) to separate dust in auxiliary boilers fired with solid fuels.

Overall, most product-specific waste-gas emissions are site-dependent (for example, they depend on the type of fuel used, the size and type of the relevant facility, whether the plant is integrated or non-integrated, whether it generates electricity). The auxiliary boilers used in Germany cover a wide spectrum of different sizes (from 10 to more than 200 MW). With smaller boilers, the only useful approach is to use low-sulphur fuels and the pertinent

combustion technologies, while secondary reduction measures can also be effective with larger boilers.

Further information about activity data is provided in Chapter 18.

19.3 Other detailed methodological descriptions for the source category "Solvents and other product use" (3)

19.4 Other detailed methodological descriptions for the source category "Agriculture" (4)

19.4.1 On use of the IPCC Guidelines 2006

In its statement of 5 September 2009, the ERT of the Centralized Review in September 2009 called for the following:

“The ERT request that Germany provide a detailed methodological description by IPCC category and gas for its agricultural inventory where Germany does not use the parameters provided in the IPCC 1996 guidance documents.”

This Chapter, therefore, presents a short description of those methods in which Germany departs from the specifications of the IPCC (1996) Guidelines and of the IPCC (2000) Good Practice Guidance. The relevant areas include – taking account of the methodological changes as a result of the in-country review of September 2010 (cf. Chapter 10.5) – Methane emissions from enteric fermentation (4.A) and from Manure management (4.B), and Nitrous oxide emissions from manure management (4.B).

The following information is based on the tables that were transmitted, to the ERT of the Centralized Review in September 2009, in answer to the above request. The tables have been updated for the NIR 2011 and, in part, supplemented with, or replaced by, text. The first column refers to gas and source; the information provided in the second column refers to the relevant chapters in the comprehensive report (RÖSEMANN et. al., 2011); the third column includes information on the methods used. The fourth column provides, for report years 1990 and 2009, the figures used in the German inventory (such as emission factors) and compares them with the corresponding figures from IPCC (1996b). In all cases, the reference "IPCC 1996" denotes IPCC (1996b).

Table 295: Methane emissions from enteric fermentation

Source	Chapter	Methodology	Effective parameter
other cattle	calves: 4.4.4 heifers: 4.5.4 bulls: 4.6.4 suckler cows: 4.7.3 mature males: 4.8.4	A Tier 2 approach is used, differentiating between calves, heifers, bulls (beef), suckler cows and mature males. Energy requirements are calculated using national data. Constants are taken from IPCC 2006 as they are updated (see reasoning in IPCC 2006, pg. 10.30). The methane conversion rate for all other cattle apart from calves is 6.5 % and thus exceeds the one proposed in IPCC 1996. In the German inventory calves are defined as cattle younger than two months. As calves within this category only gradually emerge as ruminants, a value of 2 % is used (national expertise, cf. chapter 6.2.2.3).	mean methane conversion factor 1990: 6.16 % 2009: 6.15 % IPCC 1996: 6.0 %
horses	horses: 7.2.1.2, 7.2.2, 7.3.1.2, 7.3.2	The definition of horses given in IPCC 1996 and 2006 applies to heavy horses (size, weight, energy requirements). The German inventory differentiates light horses and ponies with respect to their different properties. IPCC 1996 and 2006 fail to provide an adequate default emission factor for light horses and ponies. In order to derive an emission factor for light horses and ponies, the ratio of gross energy intakes of heavy horses and light horses (2/3, see Chapter 6.2.2.5) is assumed to apply also to the ratio of the CH ₄ emission factors..	heavy horses, default emission factor 1990: 18 kg place ⁻¹ a ⁻¹ 2009: 18 kg place ⁻¹ a ⁻¹ IPCC 1996: 18 kg place ⁻¹ a ⁻¹ light horses and ponies, emission factor 1990: 12 kg place ⁻¹ a ⁻¹ 2009: 12 kg place ⁻¹ a ⁻¹ IPCC 1996: ---

Nitrous oxide emissions from manure management:

For all relevant animal categories (cattle, pigs, poultry except geese) a detailed methodology is used to derive excretion rates (N and VS). In the mass flow approach used in any case it is important to differentiate between the various housing and storage systems, as these have an effect on CH₄, NMVOC, NH₃, N₂, NO and N₂O emissions.

For N₂O, IPCC 2006 partial emission factors are used for the German inventory, as they can be assigned to the storage systems used in Germany (see also Amon et al., 2001).

These emission factors allow for a differentiation between slurry stored with natural crust (EF = 0.005 kg kg⁻¹ N₂O-N), without a natural crust cover (EF = 0 kg kg⁻¹ N₂O-N) and slurry storage below animal confinements (EF = 0.002 kg kg⁻¹ N₂O-N). IPCC 1996 uses one single EF of 0.001 kg kg⁻¹ N₂O-N not differentiating between different slurry storage systems.

The IPCC 1996 N₂O emission factor for solid storage and dry lot is 0.02 kg kg⁻¹ N₂O-N. IPCC 2006 differentiates between a N₂O emission factor for dry lot (0.02 kg kg⁻¹ N₂O-N) and a N₂O emission factor for solid storage (0.005 kg kg⁻¹ N₂O-N). Based on a review of several central European studies, Freibauer (2003) found median emission factors for solid storage (cattle, sheep, goats: EF = 0.005 kg kg⁻¹ N₂O-N; Swine: EF = 0.002 kg kg⁻¹ N₂O-N) supporting the IPCC 2006 emission factor rather than the IPCC 1996 emission factor. Amon et al. (2001) report emission factors ranging from 0.0027 to 0.01 kg N₂O-N (kg N)⁻¹.

IPCC 1996 does not provide a default emission N₂O factor for poultry manure. Hence, the IPCC 2006 default value is used (0.001 kg kg⁻¹ N₂O-N). Freibauer (2003) cites Sneath et al. (1997) with the same value.

Methane emissions from manure management:

Generally Germany uses the IPCC 2006 methane conversion factors, because, in contrast to IPCC 1996 and IPCC 2000 Good Practice Guidance, they differentiate between slurry storage with and without natural crust and therefore enable a methane emission calculation consistent with the ammonia emission calculation in the German inventory model GAS-EM.

IPCC 2000 Good Practice Guidance uses a MCF of 39 %, IPCC 1996 a MCF of 10 % for all liquid / slurry storage systems. IPCC 2006 uses MCFs of 10 % for slurry without natural crust cover and 17 % for slurry with natural crust cover (for average annual temperatures ≤ 10 °C as this is the case for most districts in Germany). According to Dustan (2002) a MCF of 39 % is not applicable to Sweden and other countries with similar climatic conditions (mean temperatures around 7.5 °C). Furthermore he found no references to support the substantial increase in the MCF from 10 % to 39 % from IPCC 1996 to IPCC 2000. Austria is using country specific MCFs below 10 %, based on measurements (Environment Agency Austria, 2010). Hence, Germany is of the opinion that a level of 39 % is not applicable to describe the German conditions.

Table 296: Methane emissions from manure management

Source	Chapter	Methodology	Effective parameter
dairy cows	4.3.6	A very detailed approach is used to assess feed intake, energy and nutrient intake, CH₄ from enteric fermentation as well as VS and N excretion rates based on as much national information as possible. The German inventory differentiates between regional feeds, milk yields, temperatures as well as housing and storage systems. Germany differentiates between the various storage systems (e. g. crust, no crust), as these have an effect on both CH₄ and N₂O emission factors. IPCC 1996 does not allow for a differentiation between various storage systems. When IPCC 2006 is used, the mass flow can be calculated consistent with the NH₃ emissions where various storage systems are accounted for. In addition, IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 only differentiates between temperature regimes only.	maximum methane producing capacity 1990: 0.24 m³ kg⁻¹ CH₄ 2009: 0.24 m³ kg⁻¹ CH₄ IPCC 1996: 0.24 m³ kg⁻¹ CH₄ mean methane conversion factor for slurry 1990: 0.140 kg kg⁻¹ CH₄ 2009: 0.134 kg kg⁻¹ CH₄ IPCC 1996: 0.10 kg kg⁻¹ CH₄ methane conversion factor for solid storage 1990: 0.02 kg kg⁻¹ CH₄ 2009: 0.02 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄ methane conversion factor for pasture 1990: 0.01 kg kg⁻¹ CH₄ 2009: 0.01 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄
other cattle	calves: 4.4.5 heifers: 4.5.5 bulls: 4.6.5 suckler cows: 4.7.4 mature males: 4.8.5	A Tier 2 approach is used, differentiating between calves, heifers, bulls (beef), suckler cows and mature males. The German inventory differentiates between regional temperatures as well as housing and storage systems. Energy and nutrient requirements are calculated using national data. The methodology used allows the derivation of VS and N excretion rates. In a mass flow approach it is important to differentiate between the various storage systems (e. g. crust, no crust), as these have an effect on both CH₄ and N₂O emission factors. IPCC 1996 does not allow for a differentiation between various storage systems. When IPCC 2006 is used, the mass flow can be calculated consistent with the NH₃ emissions where various storage systems are accounted for. In addition, IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 only differentiates between temperature regimes only.	maximum methane producing capacity 1990: 0.18 m³ kg⁻¹ CH₄ 2009: 0.18 m³ kg⁻¹ CH₄ IPCC 1996: 0.17 m³ kg⁻¹ CH₄ mean methane conversion factor for slurry 1990: 0.138 kg kg⁻¹ CH₄ 2009: 0.133 kg kg⁻¹ CH₄ IPCC 1996: 0.10 kg kg⁻¹ CH₄ methane conversion factor for solid storage 1990: 0.02 kg kg⁻¹ CH₄ 2009: 0.02 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄ methane conversion factor for pasture 1990: 0.01 kg kg⁻¹ CH₄ 2009: 0.01 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄

Source	Chapter	Methodology	Effective parameter
pigs	sows: 5.3.5 weaners: 5.4.5 fatteners: 5.5.5 boars: 5.6.5	A very detailed approach is used, differentiating between sows, weaners, fatteners and boars. It assesses feed intake, energy and nutrient intake, VS and N excretion rates based on as much national information as possible. In a mass flow approach it is important to differentiate between the various storage systems (e. g. crust, no crust), as these have an effect on both CH ₄ and N ₂ O emission factors. IPCC 1996 does not allow for a differentiation between various storage systems. When IPCC 2006 is used, the mass flow can be calculated consistent with the NH ₃ emissions where various storage systems are accounted for. IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 only differentiates between temperature regimes.	maximum methane producing capacity 1990: 0.45 m³ kg⁻¹ CH₄ 2009: 0.45 m³ kg⁻¹ CH₄ IPCC 1996: 0.45 m³ kg⁻¹ CH₄ mean methane conversion factor for slurry 1990: 0.170 kg kg⁻¹ CH₄ 2009: 0.164 kg kg⁻¹ CH₄ IPCC 1996: 0.10 kg kg⁻¹ CH₄ methane conversion factor for solid storage 1990: 0.02 kg kg⁻¹ CH₄ 2009: 0.02 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄
sheep	6.2.3	Default IPCC 2006 VS excretion rates, maximum methane producing capacity and methane conversion factors are combined with German grazing and housing frequencies.	maximum methane producing capacity 1990: 0.19 m³ kg⁻¹ CH₄ 2009: 0.19 m³ kg⁻¹ CH₄ IPCC 1996: 0.19 m³ kg⁻¹ CH₄ methane conversion factor for solid storage 1990: 0.02 kg kg⁻¹ CH₄ 2009: 0.02 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄ methane conversion factor for pasture 1990: 0.01 kg kg⁻¹ CH₄ 2009: 0.01 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄
goats	6.6.3	IPCC 2006, Table 10.15, gives a default emission factor of 0.13 kg place ⁻¹ a ⁻¹ CH ₄ , which reflects all-year-round grazing as can be recalculated from the data set provided in IPCC 2006, Table 10A-9. Doing so, one realizes that the IPCC 1996 default emission factor is incorrect (0.12 kg place ⁻¹ a ⁻¹). Germany makes use of the default VS excretion rate, maximum methane producing capacity and methane conversion factors listed in IPCC 2006, Table 10A-9 and combines them with German grazing and housing frequencies.	implied emission factor (IEF) 1990: 0.22 kg place⁻¹ a⁻¹ 2009: 0.22 kg place⁻¹ a⁻¹ IPCC 1996: 0.12 kg place⁻¹ a⁻¹

Source	Chapter	Methodology	Effective parameter
horses	heavy horses: 7.2.3 ponies: 7.3.3	For the subdivision of horses in subcategories see above (enteric fermentation). Default IPCC 2006 VS excretion rates, maximum methane producing capacity and methane conversion factors are combined with German grazing and housing frequencies. For light horses/ponies a specific VS excretion rate is derived (2/3 of the heavy horses VS excretion) based on energy considerations (see Chapter 6.2.2.5).	maximum methane producing capacity 1990: 0.3 m³ kg⁻¹ CH₄ 2009: 0.3 m³ kg⁻¹ CH₄ IPCC 1996: 0.33 m³ kg⁻¹ CH₄ methane conversion factor for solid storage 1990: 0.02 kg kg⁻¹ CH₄ 2009: 0.02 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄ methane conversion factor for pasture 1990: 0.01 kg kg⁻¹ CH₄ 2009: 0.01 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄ implied emission factor (IEF), heavy horses 1990: 2.80 kg place⁻¹ a⁻¹ 2009: 2.80 kg place⁻¹ a⁻¹ IPCC 1996: 1.56 kg place⁻¹ a⁻¹ implied emission factor (IEF), light horses 1990: 1.82 kg place⁻¹ a⁻¹ CH₄ 2009: 1.82 kg place⁻¹ a⁻¹ CH₄
mules and asses	7.5.3	Both IPCC (1996b), Table B-7, and IPCC 2006, Table 10.15, give a default emission factor of 0.76 kg place ⁻¹ a ⁻¹ CH ₄ . Default IPCC 2006 VS excretion rates, maximum methane producing capacity and methane conversion factors for mules and asses are combined with German grazing and housing frequencies for horses.	implied emission factor 1990: 1.36 kg place⁻¹ a⁻¹ 2009: 1.36 kg place⁻¹ a⁻¹ IPCC 1996: 0.76 kg place⁻¹ a⁻¹
buffalo	8.2.3	Default IPCC 2006 VS excretion rates, maximum methane producing capacity and methane conversion factors are combined with German grazing and housing frequencies. Germany makes use of the default VS excretion rate, default maximum methane producing capacity and default methane conversion factors according to IPCC 2006, Table 10A-6. It is assumed that buffalo are kept on pasture 10 hours a day for 140 days a year. It is assumed that storage systems are slurry storage with natural crust (50 %) and solid storage (50 %). The MCF for pasture equals that of IPCC 1996.	maximum methane producing capacity 1990: 0.10 m³ kg⁻¹ CH₄ 2009: 0.10 m³ kg⁻¹ CH₄ IPCC 1996: 0.10 m³ kg⁻¹ CH₄ methane conversion factor for slurry storage 1990: 0.10 kg kg⁻¹ CH₄ 2009: 0.10 kg kg⁻¹ CH₄ IPCC 1996: 0.10 kg kg⁻¹ CH₄ methane conversion factor for solid storage 1990: 0.02 kg kg⁻¹ CH₄ 2009: 0.02 kg kg⁻¹ CH₄ IPCC 1996: 0.01 kg kg⁻¹ CH₄ Implied emission factor (IEF) 1990: 4.96 kg place⁻¹ a⁻¹ CH₄ 2009: 4.96 kg place⁻¹ a⁻¹ CH₄ IPCC 1996: 2.67 kg place⁻¹ a⁻¹ CH₄

Source	Chapter	Methodology	Effective parameter
laying hens	9.3.6	A detailed methodology is used to derive VS excretion rates on a national basis. IPCC 1996 does not differentiate between various species among poultry. So maximum methane producing capacity for laying hens and methane conversion factor for poultry manure are taken from IPCC 2006.	maximum methane producing capacity 1990: 0.39 m ³ kg ⁻¹ CH ₄ 2009: 0.39 m ³ kg ⁻¹ CH ₄ IPCC 1996: 0.32 m ³ kg ⁻¹ CH ₄ methane conversion factor 1990: 0.015 kg kg ⁻¹ CH ₄ 2009: 0.015 kg kg ⁻¹ CH ₄ IPCC 1996: 0.01 kg kg ⁻¹ CH ₄
broilers	9.4.6	A detailed methodology is used to derive VS excretion rates on a national basis. IPCC 1996 does not differentiate between various species among poultry. So maximum methane producing capacity for broilers and methane conversion factor for poultry manure are taken from IPCC 2006.	maximum methane producing capacity 1990: 0.36 m ³ kg ⁻¹ CH ₄ 2009: 0.36 m ³ kg ⁻¹ CH ₄ IPCC 1996: 0.32 m ³ kg ⁻¹ CH ₄ methane conversion factor 1990: 0.015 kg kg ⁻¹ CH ₄ 2009: 0.015 kg kg ⁻¹ CH ₄ IPCC 1996: 0.01 kg kg ⁻¹ CH ₄
pullets	9.5.6	A detailed methodology is used to derive VS excretion rates on a national basis. IPCC 1996 does not differentiate between various species among poultry. Maximum methane producing capacity and methane conversion factor for poultry manure are taken from IPCC 2006. (IPCC 2006 does not mention pullets explicitly. The data for laying hens are used accordingly.)	maximum methane producing capacity 1990: 0.39 m ³ kg ⁻¹ CH ₄ 2009: 0.39 m ³ kg ⁻¹ CH ₄ IPCC 1996: 0.32 m ³ kg ⁻¹ CH ₄ methane conversion factor 1990: 0.015 kg kg ⁻¹ CH ₄ 2009: 0.015 kg kg ⁻¹ CH ₄ IPCC 1996: 0.01 kg kg ⁻¹ CH ₄
geese	9.6.4	No national data on VS excretions are available. As neither IPCC 1996 nor IPCC 2006 provide default VS excretions, a Tier 1 method has to be applied for which the default emission factor provided by IPCC 1996 for poultry is used. (IPCC 2006 does not provide a default emission factor for geese.)	default emission factor 1990: 0.078 kg place ⁻¹ a ⁻¹ 2008: 0.078 kg place ⁻¹ a ⁻¹ IPCC 1996: 0.078 kg place ⁻¹ a ⁻¹
ducks	9.7.6	A detailed methodology is used to derive VS excretion rates on a national basis. IPCC 1996 does not differentiate between various species among poultry. So maximum methane producing capacity for ducks and methane conversion factor for poultry manure are taken from IPCC 2006. IPCC 2006, Table 10A-9, lists an MCF of 0.01 kg kg ⁻¹ CH ₄ for ducks in contrast to Table 10.17 where an MCF of 0.015 kg kg ⁻¹ CH ₄ is given for poultry. The use of the smaller MCF is considered inconsistent in comparison with other poultry keeping in mind that it is almost impossible to keep a duck house "dry". Thus, the German inventory uses an MCF of 0.015 kg kg ⁻¹ CH ₄ .	maximum methane producing capacity 1990: 0.36 m ³ kg ⁻¹ CH ₄ 2009: 0.36 m ³ kg ⁻¹ CH ₄ IPCC 1996: 0.32 m ³ kg ⁻¹ CH ₄ methane conversion factor 1990: 0.015 kg kg ⁻¹ CH ₄ 2009: 0.015 kg kg ⁻¹ CH ₄ IPCC 1996: 0.01 kg kg ⁻¹ CH ₄

Source	Chapter	Methodology	Effective parameter
turkeys	9.8.4	A detailed methodology is used to derive VS excretion rates on a national basis. IPCC 1996 does not differentiate between various species among poultry So maximum methane producing capacity for turkeys and methane conversion factor for poultry manure are taken from IPCC 2006..	maximum methane producing capacity 1990: 0.36 m ³ kg ⁻¹ CH ₄ 2009: 0.36 m ³ kg ⁻¹ CH ₄ IPCC 1996: 0.32 m ³ kg ⁻¹ CH ₄ methane conversion factor 1990: 0.015 kg kg ⁻¹ CH ₄ 2009: 0.015 kg kg ⁻¹ CH ₄ IPCC 1996: 0.01 kg kg ⁻¹ CH ₄

19.5 Other detailed methodological descriptions for the source/sink category "Land-use change and forestry" (5)

19.5.1 Forest land (5.A)

19.5.1.1 Further information about the project GSE Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT)

19.5.1.1.1 Definition of forest land and land-use categories

The definition of "forest" used by the National Forest Inventory (Bundeswaldinventur – BWI) has been used as the basis for designation of land as forest land (BMVEL 2001) (cf. Chapter 7.2.3). The BWI definition of "forest land" has been adapted as follows for purposes of this GSE project:

- Definition of a potential minimum tree height of 5 m (this produces no discrepancy with the definition of "forest land" used for purposes of the National Forest Inventory)
- Definition of a minimum coverage percentage of 30 % (in Germany, this is equivalent to a 50 % minimum coverage percentage; cf. BMVEL (2001))
- Definition of a minimum forest area of 0.5 ha (this produces a discrepancy with the BWI definition of "forest land", a discrepancy that must be taken into account in uncertainties determination and sensitivity analysis).

With these modifications, the definition of "forest land" used is consistent with that adopted in the Marrakesh Accords (GSE 2009). For designation of the six IPCC land-use categories, the relevant definitions of the IPCC Guidelines apply (IPCC 2003).

19.5.1.1.2 Data sources, data processing and evaluation, precision analysis

For the reference year 1990, Landsat TM satellite images were used. For 2002, Landsat ETM images were used, and for 2005/2006 LISS data from the Indian IRS satellites were used. A number of additional sources were also used in the analyses, including topographic models, aerial photos, ATKIS data, topographic maps and data from the BWI 2 National Forest Inventory (cf. Table 297).

Table 297: Satellite data (with relevant survey years), and additional data from the new German Länder for the GSE project (pursuant to GSE 2003, GSE 2006, GSE 2007, GSE 2009)

State (Land)	Satellite data	Survey year	Additional data
Mecklenburg – West Pomerania	IRS P6 LISS III/IV Landsat TM	2005 1989, 1990	DEM SRTM, IRS-Mosaic-Euromaps, TK 1:50.000, TK 1:25.000, ATKIS, aerial photos (2004-2005), historic aerial photos (1989-1990), BWI 2
Thuringia	IRS P6 LISS III Spot-5 Landsat TM	2005, 2006 2005 1989, 1990	DEM SRTM, IRS-Mosaic-Euromaps, Google Earth Pro-SPOT 2-5 imagery, TK 1:50.000, BWI 2
Saxony-Anhalt	IRS P6 LISS III Landsat TM	2005, 2006 1989, 1990	DEM SRTM, IRS-Mosaic-Euromaps, TK 1:50.000, 38 historic aerial photos (1989 - 1990), BWI 2
Berlin/Brandenburg	IRS P6 LISS III Landsat TM	2005, 2006 1989, 1991	DEM SRTM, IRS-Mosaic-Euromaps, Google Earth Pro-SPOT 2-5 imagery, TK 1:50.000, BWI 2
East Saxony (~80% of the state's area)	Landsat ETM Landsat TM	2002 1989	DEM Monapro, DEM SRTM, IRS-Mosaic 2000, CIR aerial photos (2000-2002), TK 1:25.000, biotope map of Saxony 1:25000, ATKIS-Waldlayer, BWI 2
West Saxony (~20% of the state's area)	IRS P6 LISS III Landsat TM	2006 1989, 1990	DEM SRTM, IRS-Mosaic-Euromaps, Google Earth Pro-SPOT 2-5 imagery, TK 1:50.000, BWI 2

Following geometric processing of the data, the data are thematically analysed. That work includes such steps as classification of forest areas, quality assurance for such classification and analysis of the changes that have occurred in the various land-use categories. The change analysis was carried out via a two-step procedure. First, the forest and non-forest areas shown in current satellite data were compared with the historic Landsat TM data from the years 1989-1991, and the relevant changes were listed. Then, a further, qualitative evaluation of the non-forest areas divided, via comparison of the satellite-data sets for different survey times, into the land-use categories settlement, grassland, cropland, wetlands and other land. The precision of the forest / non-forest maps, as well as of the maps of land use and land-use changes, was then determined via comparison of a random number of sample points with Google Earth data or aerial photos. The results of the precision analysis have been compiled within various statistics (GSE 2003, GSE 2006, GSE 2007, GSE 2009). The sampling errors for the area estimates for the new German Länder, for the period 1987 – 2002, are shown in Table 204 in Chapter 7.2.5.1.

19.5.1.1.3 Adaptation of the results of the GSE FM-INT project

In the GSE project, forest-land parcels with an area of at least 0.5 hectares were categorised. That categorisation produced some discrepancies with forest areas as determined in accordance with the definition of "forest" used in the National Forest Inventory (BWI). That leads to inconsistent land-use matrices for the old German Länder and the new German Länder, for the period 1990 – 2008, as well as to inconsistencies in the land areas for the subsequent period. For this reason, a consistent land-use matrix, for the old German Länder and the new German Länder, is also being prepared for the period (1990-2002) for which no common database for the relevant forest areas is available. To that end, an analysis of land use and land-use changes is being carried out, on the BWI grid, and using all available data sources, including GSE FM-INT, BWI data and aerial photos, for the areas derived from the GSE project – especially for areas with sizes between 0.1 and 0.5 ha. The

survey system is thus being adapted to the BWI sampling grid for those areas as well. As a result, it is assured that the land-use matrix has the best-possible spatial and chronological consistency.

For purposes of IPCC-conformal greenhouse-gas reporting, however, the land-use-category area statistics provided via this GSE project had to be slightly modified. The IPCC does not recognise the land-use categories "temporarily unforested land" and "forest – unforested area". Via pertinent review, with the help of other data sources, such as ATKIS, it was determined that such areas are part of "forest land remaining forest land". As a result, both of these categories were assigned to the category "forest land remaining forest land". A similar procedure was followed for the category "forest – other land", which was assigned to the category "settlement", and for "other land – forest", which was assigned to the category "grassland". These changes have been taken into account in the land-use matrix for the new German Länder (cf. Table 190 and Table 191 in Chapter 7.2.3.2).

The results of the GSE project included clear geographic delimitation of new-forest, forest land converted to other land and managed-forest areas (cf. Figure 66). Further relevant information and results are presented in the project's final reports (GSE 2003, GSE 2006, GSE 2007, GSE 2009).

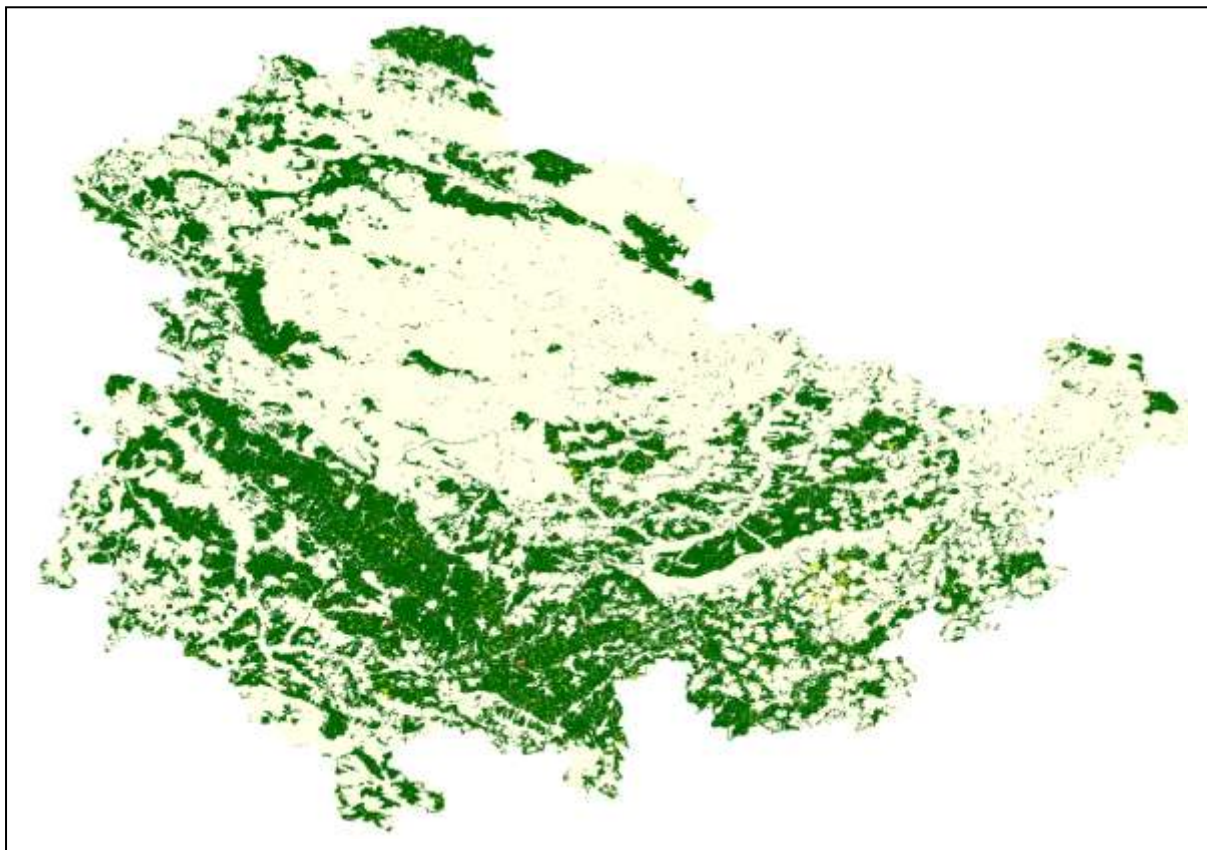


Figure 66: Map of the state of Thuringia with the land-use categories "afforestation" (yellow), "forest land converted to other land" (red) and "managed forest land" (green)

19.5.1.2 Uncertainties and time-series consistency

19.5.1.2.1 *Error budget*

Finally, the error sources and error frameworks described in Chapters 7.2.5.1 to 7.2.5.2.4 are combined to form a total error budget. For the old German Länder, and for the period 1987 – 2002, a complete budget can be prepared. For the old German Länder, Table 298 shows the total error budget for C-stocks estimation for 1987, while Table 299 shows the corresponding figure for 2002. The total error budget for C-stocks changes between 1987 and 2002, in the old German Länder, is shown in Table 300. For the period 2002 – 2008, the data permit such an error budget only for the category Forest Land remaining Forest Land. The total error budget for the C-stocks and C-changes estimates for the land-use category Forest Land remaining Forest Land, between 2002 and 2008 in Germany, is summarised in Table 301.

Table 298: Total error budget for estimation of biomass C-stocks for the year 1987, in the old German Länder

1987															
LULUCF category	area		above-ground					below-ground				carbon		overall	
	[ha]	error [%]	biomass stock [t]	se [%]	vef [%]	rd [%]	error total [%]	biomass stock [t]	se [%]	root-shoot-ratio [%]	error total [%]	carbon stock [t]	carbon error [%]	error total [%]	error emission factor [%]
Forest Land remaining Forest Land	7,599,965	0.93	1,235,448,107	1.07	2.99	9.19	9.73	351,236,001	1.05	25.37	25.39	793,342,054	2.00	9.64	9.68
Forest Land converted to Cropland	5,290	26.51	272,142	55.12	2.12	13.7	56.84	92,680	55.59	32.36	64.32	182,411	2.00	45.48	52.64
Forest Land converted to Grassland	24,634	14.18	351,457	45.42	2.81	8.65	46.32	121,383	43.11	24.19	49.43	236,420	2.00	36.75	39.39
Forest Land converted to Settlements	39,688	11.14	3,047,746	18.73	2.14	7.92	20.45	920,259	18.49	22.43	29.07	1,984,003	2.00	17.21	20.5
Forest Land converted to Wetlands	9,133	24.85	90,532	69.85	3.08	24.49	74.08	28,229	64.93	32.34	72.54	59,380	2.00	59.08	64.10
Forest Land converted to Other Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Cropland converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Grassland converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Settlements converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Wetlands converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Other Land converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Aforestation	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Deforestation	78,744	8.01	3,761,878	16.33	2.14	8.21	18.4	1,162,550	16.01	23.09	28.10	2,462,214	2.00	15.67	17.60

Table 299: Total error budget for estimation of biomass C-stocks for the year 2002, in the old German Länder

2002															
	area		above-ground					below-ground				carbon		overall	
LULUCF category	[ha]	error [%]	biomass stock [t]	se [%]	vef [%]	rd [%]	error total [%]	biomass stock [t]	se [%]	root-shoot-ratio [%]	error total [%]	carbon stock [t]	carbon error [%]	error total [%]	error emission factor [%]
Forest Land remaining Forest Land	7,599,965	0.93	1,452,377,845	1.04	2.84	8.63	9.15	413,033,737	1.03	23.86	23.88	932,705,791	2.00	9.09	9.14
Forest Land converted to Cropland	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Grassland	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Settlements	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Wetlands	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Other Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Cropland converted to Forest Land	28,425	13.59	691,595	26.46	2.11	8.05	27.74	267,035	25.41	29.27	38.76	479,315	2.00	22.83	26.57
Grassland converted to Forest Land	52,974	8.61	1,956,486	15.37	2.07	7.76	17.35	683,983	14.8	26.61	30.45	1,320,235	2.00	15.21	17.48
Settlements converted to Forest Land	28,967	13.32	1,223,087	20.9	2.00	6.83	22.08	429,918	20.93	25.24	32.79	826,502	2.00	18.54	22.83
Wetlands converted to Forest Land	16,469	15.92	454,997	28.42	1.04	6.65	29.21	167,610	28.31	17.95	33.52	311,303	2.00	23.26	28.18
Other Land converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Aforestation	126,834	6.00	4,326,165	10.47	2.7	6.96	12.86	1,548,546	10.23	24.79	26.81	2,937,355	2.00	11.98	13.4
KP Deforestation	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–

Table 300: Total error budget for biomass-C-stocks changes between 1987 and 2002, in the old German Länder

1987 – 2002															
	area		above-ground					below-ground				carbon		overall	
LULUCF category	[ha]	error [%]	biomass stock [t]	se [%]	vef [%]	rd [%]	error total [%]	biomass stock [t]	se [%]	root-shoot-ratio [%]	error total [%]	carbon stock [t]	carbon error [%]	error total [%]	error emission factor [%]
Forest Land remaining Forest Land	7,599,965	0.93	216,929,738	2.94	2.06	6.29	7.25	61,797,736	2.68	17.38	17.59	139,363,737	2.00	7.14	7.20
Forest Land converted to Cropland	5,290	26.51	272,142	55.12	2.12	13.7	56.84	92,680	55.59	32.36	64.32	182,411	2.00	45.48	52.64
Forest Land converted to Grassland	24,634	14.18	351,457	45.42	2.81	8.65	46.32	121,383	43.11	24.19	49.43	236,420	2.00	36.75	39.39
Forest Land converted to Settlements	39,688	11.14	3,047,746	18.73	2.14	7.92	20.45	920,259	18.49	22.43	29.07	1,984,003	2.00	17.21	20.50
Forest Land converted to Wetlands	9,133	24.85	90,532	69.85	3.08	24.49	74.08	28,229	64.93	32.34	72.54	59,380	2.00	59.08	64.10
Forest Land converted to Other Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Cropland converted to Forest Land	28,425	13.59	691,595	26.46	2.11	8.05	27.74	267,035	25.41	29.27	38.76	479,315	2.00	22.83	26.57
Grassland converted to Forest Land	52,974	8.61	1,956,486	15.37	2.07	7.76	17.35	683,983	14.80	26.61	30.45	1,320,235	2.00	15.21	17.48
Settlements converted to Forest Land	28,967	13.32	1,223,087	20.90	2.00	6.83	22.08	429,918	20.93	25.24	32.79	826,502	2.00	18.54	22.83
Wetlands converted to Forest Land	16,469	15.92	454,997	28.42	1.04	6.65	29.21	167,610	28.31	17.95	33.52	311,303	2.00	23.26	28.18
Other Land converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Aforestation	126,834	6.00	4,326,165	10.47	2.7	6.96	12.86	1,548,546	10.23	24.79	26.81	2,937,355	2.00	11.98	13.40
KP Deforestation	78,744	8.01	3,761,878	16.33	2.14	8.21	18.4	1,162,550	16.01	23.09	28.1	2,462,214	2.00	15.67	17.60

Table 301: Total error budget for estimation of biomass C stocks and biomass-C-stock changes, in the category Forest Land remaining Forest Land, between 2002 and 2008, in Germany

	area		above-ground					below-ground				carbon		overall	
year	[ha]	error [%]	biomass stock [t]	se [%]	vef [%]	rd [%]	error total [%]	biomass stock [t]	se [%]	root-shoot-ratio [%]	error total [%]	carbon stock [t]	carbon error [%]	error total [%]	error emission factor [%]
2002	10,548,814	0.74	1,896,308,201	2.01	1.76	7.14	7.63	540,084,766	1.98	19.15	19.25	1,218,196,483	2.00	7.58	7.62
2008	10,548,814	0.74	1,940,334,277	2.00	1.71	6.86	7.35	553,315,973	1.97	18.48	18.59	1,246,825,125	2.00	7.33	7.36
2002-2008	10,548,814	0.74	44,026,076	27.20	1.23	24.49	36.62	13,231,207	22.98	32.34	39.67	28,628,642	2.00	29.68	29.69

19.5.1.3 Forest Land converted to Other Land

19.5.1.3.1 Source category description

The forest areas that have been converted to other forms of land use are added to the category "forest land converted to other land". In the framework of climate reporting, they remain 20 years in that category; in the framework of Kyoto reporting, they remain in that category until the end of the 2012 commitment period. While they are smaller than the new-forest-land areas, they had larger average biomass stocks prior to their conversion. In conversion, such stocks are normally removed, and thus they are considered C emissions in the year in which conversion takes place.

The emission factors derived from biomass losses, and from the areas calculated for each relevant year since 1987, decreased continuously from 1990 to 2009. This does not reflect any true trend, however; it results simply in that areas have been listed separately only since 1987, and not for the past 20 years, as called for by the IPCC (1990). As a result, the area has increased in each report year.

In addition to biomass, C stocks in dead wood and forest-floor litter, and part of the carbon in the soil, are lost in deforestation. Burning of biomass, in conversion of forest, as well as mineralisation processes occurring via plowing and turning of topsoil, can cause both CO₂ emissions and additional greenhouse-gas emissions.

19.5.1.3.2 Stock losses on forest land converted to other land

For the period 1987 to 2002 in the old German Länder, and for the period 2002 to 2008 in all German Länder, extrapolation was carried out for this category on the basis of individual-tree data from the National Forest Inventories and from the Inventurstudie (Inventory Study) 2008 (samples, Tier 2). In addition, the C stocks for the "forest land converted to other land" areas were estimated (cf. Chapter 7.2.4.1.3).

The C stocks of the old German Länder, in this category for the period from 1987 to 2002, were applied to the "forest land converted to other land" areas in the new German Länder, since the Datenspeicher Waldfonds forest database does not provide any information in this regard. The C emissions that are assigned to these areas are higher, as a result of their stock accumulations, than C binding by new forest lands. All in all, total stocks of some - 227.674 GgC were lost in this category, from biomass (not including the biomass of the converted land) in 2009. As a simplification, it was assumed that C stocks are emitted into the atmosphere in the year in which they are converted.

The C-stock differences between the 5 "forest land converted to other land" LULUCF categories (5.B.1 through 5.F.1) were not studied in detail, since too few sampling elements are available for that purpose. Such study, in other words, would provide illusory precision, i.e. "precision" that would disappear within sampling errors and in the other error categories.

In addition to losses of biomass in connection with conversion of forest land, other types of losses must be considered as well, including losses in the areas of dead wood, litter, mineral soils and organic soils. All such losses are assumed to take the form of emissions in the year of conversion. Table 302 provides an overview of carbon-stock losses, for "forest land converted to other land", for the period as of 2008. In light of the great variability, by area, of dead-wood, litter and soil stocks, these figures are subject to very large uncertainties. The

total relevant emissions could be more precisely estimated by linking the BWI points affected by deforestation with soil maps or with the nearest BZE points.

Table 302: Carbon-stock losses from biomass (including the biomass of the converted land), dead wood, litter and mineral and organic soils, for "forest land converted to other land" as of 2008

Pool	Carbon-stocks loss [Gg C]	
	2008	2009
Biomass	-130.423	-127.323
Dead wood	-22.642	-23.296
Forest-floor litter	-135.262	-133.823
Mineral soil	-3.860	-3.860
Organic soil	-1.278	-1.278
Total	-293.465	-289.580

19.5.1.4 Supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

19.5.1.4.1 *Requirements pertaining to forest management, and forest planning, pursuant to the Federal Forest Act (BWaldG) and state forest acts (Landeswaldgesetze; LWaldG)*

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), "forests are to preserved, to be increased as necessary and to be properly and sustainably managed, in light of their economic value (utility function) and of their importance with regard to the environment, especially the long-term vitality of natural systems and cycles, and with regard to climate, water cycles, air quality, soil fertility, landscape beauty, agrarian structures and infrastructure and the population's needs for rest and recreation (protection and recreation functions)".

Forests are thus assigned three key basic functions, nämlich utility, conservation and recreation functions, in light of which they are to be preserved and properly and sustainably managed. In addition, Art. 11 (1) p. 1 BWaldG mandates that "forests (...) (should) be properly and sustainably managed, in the framework of their purposes." On the one hand, that provision does not state that forests "must" be managed, and thus no general obligation applies in this regard. On the other hand, the provision also does not state that forests "may" be managed, i.e. does not use wording that would rule out a relevant obligation. The wording chosen thus reveals a certain basic orientation – namely, that forests should be managed. A certain obligation, in some sense, to manage forest lands thus applies to the country's entire territory⁸⁸. In keeping with the three basic functions / overarching purposes seen, forests can be grouped into three basic categories: utility (timber) forest, conservation forest and recreation forest. As a rule, for all three categories, management should be proper and sustainable. Management methods differ in accordance with purposes of the forest areas involved. A utility (timber) forest, whose primary purpose is to yield wood, must of course be managed differently than a conservation forest would be managed. In general, all functions

⁸⁸ Häusler and Scherer-Lorenzen (2002) speak of an obligation, for all forest owners, "to carry out sustainable, proper management"; the citation appears in: Nachhaltige Forstwirtschaft in Deutschland im Spiegel des ganzheitlichen Ansatzes der Biodiversitätskonvention. BfN – Skripten 62, p. 5 and 15.

are to be kept in mind in forest management, however. This means, for example, that conservation and recreation functions are also to be upheld in a utility forest (cf. especially Art. 4 (1) LWaldG Berlin⁸⁹, and Art. 4 (2) Forest Act (WaldG) of Saxony-Anhalt⁹⁰). As a rule, integrated forest conservation is practiced in Germany (BMVEL, NWP, 2003). In such conservation, no basic distinction is made between economic-only (utility) and conservation forests; conservation measures are an integral part of forest use. Pursuant to the definition in the IPCC Good Practice Guidance LULUCF (2003) and in the Marrakesh Accords, "forest management (...) is a system of practices for stewardship⁹¹ and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner"⁹².

In the interest of protecting the forest's three basic functions, forest, pursuant to Art. 1 No. 1 in conjunction with Art. 11 (1) p.1 BWaldG, should be protected and properly and sustainably managed. The aim of proper forest management as set forth by IPCC GPG LULUCF (2003) thus accords with the requirements set forth by the Federal Forest Act (BWaldG). In both cases, management is oriented to the aim of ensuring that the forest can continue to fulfill its functions in perpetuity.

Furthermore, the IPCC defines forest management as "a system of practices". That indicates that management involves actions / measures. A forest area that is left untouched, and for which no measures are taken, is thus not a managed forest area. For a forest to qualify as "not managed", however, no human activities may take place in it, i.e. no active human interventions may be permitted in it (equivalent to MCPFE conservation category 1.1). Forest areas meeting those criteria are "practically non-existent" in Germany (BMELV, 2009). In 2007, forest conservation areas in which permitted human interventions are restricted to a minimum, i.e. fully protected areas (MCPFE conservation category 1.2), accounted for 1.1% of Germany's total forest area, and were tending to be enlarged (BMELV, 2009). The primary focus with regard to such forest areas is on biotope and species conservation (for example, protected forests, natural forest reserves, core zones of national parks and biosphere reserves). Certain types of interventions are expressly permitted, however (for example, measures to control wildfires, hoofed game, diseases or explosive growth of insect-pest populations⁹³). For protected forests, as for all protected areas, concepts are to be prepared that set forth / define / describe the object/focus of protection, the protection purpose, the necessary requirements and prohibitions for achieving the protection purpose and the necessary relevant care, management, development and restoration measures⁹⁴ (for example, in ordinances or guidelines on protected areas; cf. for example, Art. 23 (2) State Forest Act (LWaldG) of Mecklenburg – West Pomerania). In addition, some 23% of

⁸⁹ Where special functions are designated, spatially, for a forest, measures should be planned that serve the forest's other functions.

⁹⁰ In forest management, the environment, natural systems and cycles and natural assets should all be protected and cared for. The landscape's diversity and unique natural characteristics should be respected, adequate habitats should be protected, or restored, for native flora and fauna, and possibilities for outdoor recreation should be safeguarded and developed.

⁹¹ Stewardship is also covered by the definition of proper forest management, which is very similar; cf. Art. 19 (1) Thuringian Forest Act, "Proper forest management is a management method that, in keeping with reliable scientific findings and proven rules from practical experience, utilises, rejuvenates, cares for and protects the forest. It simultaneously protects the forest's economic and ecological functions, thereby protecting the sustainability of its material and non-material functions.

⁹² (Original citation).

⁹³ In addition, environmentally compatible measures to develop forests for recreational purposes and for nature-compatible research are permitted.

⁹⁴ Cf. for example, Art. 22 (1) Federal Nature Conservation Act (BnatSchG).

Germany's forest area consists of protected areas whose conservation purpose is actively assured via management measures (MCPFE conservation category 1.3); 56% consist of forests whose primary purpose is to conserve landscapes and specific natural elements (MCPFE conservation category 2); and 34 % have the primary purpose of providing protective functions (MCPFE conservation category 3). In MCPFE conservation categories 1.3 through 3, management is to be oriented to the relevant conservation purpose. Consequently, those categories fulfill forest-management requirements pursuant to IPCC GPG LULUCF (2003). Human activities for protecting conservation areas are also certainly allowed in category 1.2. Pursuant to IPCC GPG LULUCF (2003), such areas thus fulfill forest-management criteria in accordance with Art. 3.4 KP: "For example forested national parks (...) where these parks are managed to fulfil relevant ecological (including biodiversity) and social functions, and are subject to forest management activities such as fire suppression, a country may choose to include these forested national parks as lands subject to forest management"⁹⁵. It should be noted that the aforementioned area shares in the different forest-conservation categories cannot simply be summed, since they overlap to some extent; in some cases, the same forest area will have been repeatedly included (BMELV, 2009).

Much of Germany's forest lands are planned. It may be assumed that forest-management plans (economic plans, operational plans or reports) are in place for about $\frac{3}{4}$ of the country's forested area (BMELV, 2009). In addition to such operational plans, in many cases forest landscape plans (forest framework plans) are also prepared for forests, in the framework of landscape planning⁹⁶. The aim of forest framework planning is to "safeguard the forest functions necessary for the development of ecological and economic conditions pursuant to Art. 1 No. 1 (BWaldG)". That accords precisely with the aim prescribed by IPCC GPG with respect to forest management. To that end, measures may be, or must be, prescribed (cf. for example, Art. 6 (3) No. 4 p. 2 BWaldG old version; Art. 6 (1) No. 2 Bavarian Forest Act (BayWaldG); Art. 9 (4) State Forest Act (LWaldG) of Mecklenburg – West Pomerania; Art. 6 p. 2 Forest and Landscape Act of the State of Lower Saxony (NWaldLG); Art. 7 (1) State Forest Act for the State of North Rhine – Westphalia (LFoG NRW); Art. 6 (2) Forest Act of the State of Saxony-Anhalt (WaldG Sachsen-Anhalt)⁹⁷). In some cases, requirements explicitly call for such planning to serve as a guideline for management, inter alia (cf. Art. 8 (3) LFoG NRW).

All in all, it must thus be considered confirmed that all forests in Germany are managed in accordance with forest-management criteria as set forth by the IPCC GPG LULUCF (2003).

A compilation of excerpts from state forest acts, relative to requirements for forest management and for forest framework planning, is provided by STEUK (2010). A pertinent summary is presented in Table 303.

⁹⁵ IPCC Good Practice Guidance LULUCF (2003) Chapter 4.2.7.2, p. 4.62 f.

⁹⁶ Until 2005, the Federal Forest Act (BWaldG) required the preparation of forest framework plans. The relevant provisions have since been eliminated, however, as a result of the great differences, from Land to Land, in relevant planning. Cf. BMELV (2009) Waldbericht der Bundesregierung (Forest report of the Federal Government), p. 28.

⁹⁷ For definition of measures in operational plans, cf. Art. 5 (6) p. 3 State Forest Act (LWaldG) of Schleswig-Holstein.

Table 303: Overview of obligations relative to forest management, preparation of plans and use of forest framework plans, as set forth by the forest acts of the Länder

Legend:

State (Land)	Forest-management obligations			Obligations to prepare plans (economic plans, operational plans, operational reports or other specialised forest-management plans)			Obligations to prepare forest framework plans
	State forest	Municipal forest	Private forest	State forest	Municipal forest	Private forest	
Baden-Württemberg	X	X	X	X	X	(X)	(X)
Bavaria	X	X	X	X	[X]		(X)
Berlin	X	X	X				X
Brandenburg							X
Bremen	X	X	X				
Hamburg	X	X	X				X
Hesse	X	X	X	X	X	[X]	
Mecklenburg – West Pomerania	X	X	X				X
Lower Saxony	X	X	X	[X]	[X]		X
North Rhine – Westphalia	X	X	X		X		X
Rhineland-Palatinate	X	X	X	[X]	[X]	[X]	X
Saarland	X	X	X	X	X	(X)	X
Saxony	X	X	X	X	X		(X)
Saxony-Anhalt	X	X	X	X	X		X
Schleswig-Holstein				[X]	[X]		
Thuringia	X	X	X	X	X	[X]	X

X Binding requirement (includes "should" requirements)

[X] Requirement is binding only under certain conditions (for example, conditions pertaining to minimum size)

(X) Optional guideline / not binding (a "can" requirement)

19.5.1.4.2 Comparison of international and national definitions of forest management

International definition pursuant to IPCC GPG LULUCF (2003):

"'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner."

National definitions pursuant to state forest acts (Landeswaldgesetze - LWaldG):

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), the purpose of the Act is, in particular, "to conserve forest for the sake of its economic value (utility function) and for the sake of its (...) (conservation and recreation function), to increase it, if necessary, and to assure its proper management in a lasting way". Pursuant to Art. 11 (1) p. 1 BWaldG, "forests (...) (should) be properly and sustainably managed, in the framework of their purposes." Because the Federal Government's legislative competence is restricted in this area, the Federal Government simply provides a framework within which the Länder enact and implement specific relevant legislation (cf. Art. 5 and Art. 11 (1) p. 2 BWaldG). As a result, the Länder define what is to be understood by "proper and sustainable forest management". A compilation of relevant sections of Länder forest acts is provided by STEUK (2010).

The forest-management requirements pursuant to Länder forest acts are comparable to those set forth by IPCC GPG LULUCF (2003). The requirement that forests are to be managed sustainably, with a view to fulfilling ecological (including biological diversity), economic and social functions,⁹⁸ is found in all Länder forest acts. In Germany, ecological, economic and social functions are often referred to as "conservation, utility and recreation" functions⁹⁹ (cf. Table 304). Where the ecological, economic and social functions that are to be served by management are not referred to explicitly as such in Länder laws, the laws add the phrase "within the framework of its purposes"¹⁰⁰. Forests are thus to be managed sustainably, within the framework of their purposes. This orientation is found in Art. 1 BWaldG (purpose of the act), which appears verbatim in every Land forest act. In addition, Art. 1 No. 1 BWaldG sets forth that forests are to be protected especially "in light of their economic value (utility function) and their (...) (conservation and recreation functions)". The aim of protecting economic, ecological and social functions is thus found in all such laws. Furthermore, both the Federal Forest Act (BWaldG) and the Länder acts impose the requirement of sustainability.

Table 304: Comparison of forest functions pursuant to the Federal Forest Act and the IPCC

Forest functions pursuant to BWaldG	Forest functions pursuant to IPCC
Utility function	Economic functions
Conservation function	Ecological functions
Recreation function	Social functions

⁹⁸ Cf. Art. 4 No. 1 BayWaldG; Art. 1a LFoG NRW; a similar meaning also is seen in Art. 6 (1) LWaldG RLP; and a similar meaning is seen in Art. 18 (1) in conjunction with Art. 19 (1) p. 2 ThürWaldG.

⁹⁹ Cf. Art. 1 No. 1 BWaldG; Art.13 LWaldG BW; Art. 11 (2) No. 1 LWaldG B; Art. 4 (2) LWaldG Bbg; Art.5 (1) BremWaldG, Art. 6 (1) HeFoG; Art. 6 (1) No. 1 LWaldG MV; Art. 11 (1) NWaldLG; Art. 5 (1) LWaldG SH.

¹⁰⁰ Cf. Art. 6 (1) LWaldG Ha; Art. 11 (1) LWaldG SL; Art. 17 SächsWaldG; Art. 4 (1) WaldG LSA; Art. 18 (1) ThürWaldG.

19.5.2 Cropland, grassland, wetlands, settlements and other areas (5.B/5.C/5.D/5.E/5.F)

19.5.2.1 Land-area distribution and allocation of usage categories

For the present inventory a mixed approach is being used, for the first time, for designation of land use and land-use changes in Germany; this approach links the results of the sampling inventory for the forest sector (BWI, cf. Chapter 7.2) with those of the GIS-controlled "wall-to-wall" approach for areas outside of forested areas. In addition, the land-use areas and land-use changes have been completely recalculated for the period 1990 – 2000. Figure 46 and Figure 47 in Chapter 7.1 provide an overview of the German reporting system relative to LULUCF.

19.5.2.1.1 Procedures

19.5.2.1.1.1 Sampling inventory

A sample/sampling is a selection of objects that represent, and provide information about, a basic whole. Measurements, or study etc., of samples are used to develop conclusions about the entire whole in question. To be statistically significant, sampling must cover a sampling must cover a representative cross-section of the basic whole concerned. There are various different methods for selecting sample sets in sampling. For the National Forest Inventory, for example, a systematic sampling procedure is used. Further information, and a detailed description of that procedure, are presented in Chapter 7.2.2.1.

19.5.2.1.1.2 Wall-to-wall approach

For identification and spatial allocation of land-use categories, complete-coverage digital maps and data records were used, in a GIS-technology framework. Via comparison with data records of various relevant years, land-use changes throughout Germany were identified. All such data was georeferenced. The resulting data records were then linked with land maps and with official statistical data. That made it possible, ultimately, to estimate the carbon-stock changes in the soil and in biomass.

Data sets were processed with the PostgreSQL database system, with an added PostGIS module, and with scripts of our own developed especially for this purpose. For the overall system, and its calculation processes, this approach ensures transparency, consistency, comparability and completeness.

19.5.2.1.1.3 Data sources and their adaptation

Folgende Datenquellen wurden für die Erstellung der GIS-basierten Landnutzungsmatrices verwendet:

- Basic digital landscape model of ATKIS® (AdV). Data sets for 2000, 2005, 2006, 2007, 2008, 2009
- 2005 Administrative-boundaries database of ATKIS®
- Digital soil map of Deutschland, 1:1.000.000 (BUEK 1000) (BGR 1997)
- Data from official German statistics (*Federal Statistical Office*)
 - Main soil-use survey (Bodennutzungshaupterhebung) 1991, 1999, 2003, 2007
 - Harvest survey, 1989 - 2008
 - Data from the district reform of 2007

In order to make it possible for all data to be compared and used/mixed in calculations, the georeferenced area data of all pertinent systems were normed using the administrative-boundaries data records in the ATKIS[®] system (VG 250).

ATKIS[®], the "official topographic-cartographic information system of Germany" ("Amtliches Topographisch-Kartographisches Informationssystem Deutschlands"), maintained by the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV; Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder), is the heart of the system for showing land use and land-use changes via a "wall-to-wall" approach. The ATKIS[®] system uses digital landscape and terrain models to represent Germany's surface. The "basic digital landscape model" (Basis-Digitale Landschaftsmodell; Basis-DLM) of ATKIS[®] serves as the basis for the digital landscape models and other information provided in German LULUC reporting. "The Basis-DLM uses a vector format to describe topographic objects of the landscapes and the relief of the earth's surface. Each object is assigned to a specific object type and defined in terms of its spatial position, geometric type, descriptive attributes and relations to other objects. Each object has an identification number (identifier) that is unique throughout all objects for Germany. In the Basis-DLM, spatial position is given true to scale, and independently of any representations, within the coordinate system used for land surveying. The object types contained in the DLM, and the manner in which the objects are to be formed, are defined in the ATKIS[®] object-type catalogue (ATKIS[®]-OK)" (AdV¹⁰¹). The informational spectrum of the Basis-DLM is oriented to the contents of standard 1:25,000 topographic maps. At the same time, the Basis-DLM features greater precision of position ($\pm 3\text{m}$) for the most important point-shaped and line-shaped objects. Data of the Basis-DLM systems of the Länder are adopted by the Federal Agency for Cartography and Geodesy (BKG) and then checked, harmonised, georeferenced and processed, without any overlapping, for use within a nationally standardised Basis-DLM. The BKG also manages the data, within a special database, for purposes of provision to federal authorities and other agencies.

The purpose of ATKIS[®] is to provide a maximally current, high-resolution landscape model (land cover) of Germany, with regularly updated and expanded geometries and content. Data are collected by the surveying authorities of the Länder. They are not collected on nationwide sampling days, however; they are collected continuously. As a result, new surveying results are continuously transmitted to the Federal Agency for Cartography and Geodesy (BKG) and integrated within ATKIS[®]. The data are completely revised, at the Länder level, every five years or as otherwise necessary. For areas of central current interest, especially with regard to changes – for example, settlement and transport areas – efforts are normally made to transfer relevant data into the ATKIS[®] system within 3 – 12 months.

The Basis-DLM version maintained and managed by the BKG is always the latest version. No pertinent history data are recorded, nor are old versions archived.

For the reporting agency in the present context, this means:

- Basis-DLM are obtained on an annual basis; the Basis-DLM for a given report year is obtained in September of that year;
- In each case, the version for the current year is archived.

¹⁰¹ ATKIS[®] Objektartenkatalog (object-type catalogue; last checked, 5 November 2010), URL:
http://www.atkis.de/dstinfo/dstinfo.dst_start?dst_oar=4101&inf_sprache=deu&c1=1&dst_typ=25&dst_ver=dst&dst_land=ADV

For these reasons, Basis-DLM data records have been available to the reporting agency, on an annual basis, only since 2005. By chance, it proved possible to obtain a data record for the year 2000, from the "early days of ATKIS®". No ATKIS® data exist for years prior to 2000.

19.5.2.1.1.4 Inconsistencies and system change

There are no ATKIS® data for the base year 1990 and the period until the year 2000. To fill that gap, the land-use-changes matrices for those years were created with data records of the CORINE Land Cover programme, harmonised with the ATKIS® data. Careful analyses of the CORINE and ATKIS® (BASIS-DLM) data have shown that, because the CORINE data tend to be less precise and have lower resolution, it is not feasible, with the existing GIS system, to produce a consistent land-use matrix and time series for the period 1990 through 2000 – and, thus, for the entire report period. The CORINE land-use map is not consistent with the land-use map of ATKIS (cf. NIELAND 2009). As a result, a new, consistent reconstruction of land use for the years prior to 2000 had to be carried out (cf. Chapter 19.5.2.6).

For this reason, inconsistencies within the ATKIS data records occurred, especially with regard to the forest sector. Those inconsistencies have to do with the development and structuring of the system, which took place in three implementation phases (the third phase was completed in 2008). As the data set was improved, surveys were refined and technical corrections were repeatedly carried out. Since the B-DLM data set is continually updated, and older versions are not archived, for systemic reasons, such technical area changes were, logically enough, identified as land-use changes. In the report system, such land-use changes resulting from technically based boundary changes cannot be differentiated from actual land-use changes. Consequently, system-related artifacts and actual land-use changes have been reported together. That, in turn, has led to overestimation of land-use changes and to imprecision, especially in the forest sector and conversions from forest to other land-use categories. And yet this area has to be handled especially carefully in the framework of Kyoto reporting.

All in all, these considerations led to the conclusion that the German LULUC reporting system needs to be completely changed – to an approach using a point grid, similar to the methods used for sampling inventories in forest reporting (cf. Chapter 19.5.2.6). The conversion is expected to accomplish the following:

- Standardise the German LULUCF reporting system,
- Prevent the artifacts that can result from mixing of different approaches,
- Produce a maximally precise, standardised description of the entire report period, especially for the years 1990 – 2000,
- Establish complete consistency between KP reporting and UNFCCC reporting.

Since it takes one to two years to fully convert the report system, for the present submission the interim solution described in Chapter 19.5.2.1 has been used, in which the results of the sampling inventory in the forest sector (BWI, cf. Chapter 7.2) are combined with those of the GIS-controlled "wall-to-wall" approach for the areas outside of forest land.

In the process, all area data that have to do with forest – i.e. "forest land remaining forest land" and land-use changes from other land-use categories to forest and vice-versa – have been taken from the results of the forest sampling inventory and entered, as a fixed reference, in the land-use-changes matrix from the wall-to-wall approach.

To obtain consistent land-use areas under these conditions, one requires a precisely defined, unchanging land area for Germany. Via the ATKIS® data set of administrative boundaries (VG 250), from 2005, that area has been set at 357,796.3 km², and the areas within the B-DLM data set have been normed on the basis of that land area.

19.5.2.1.1.5 Reconstruction of land use in 1990

The data for the years 1990 – 2000 were reconstructed on the basis of the results of the land-use-changes matrix, which was prepared for the years 2000 – 2005 with the help of the B-DLM data. On the basis of the land-use areas in 2000, the data of the land-use-changes matrix for one year were then used to retroactively reconstruct land use and its changes to 1990. That, then, assured the consistency of the land-use matrices and the time series.

Table 305 shows the so-determined land use for 1990, in comparison to the data from official statistics (land survey (Flächenerhebung) and main soil-use survey (Bodennutzungshaupterhebung), CORINE data and the data set reported until now, which is a compilation of data from official statistics and from the CORINE programme, and whose areas were corrected with the ATKIS data).

Table 305: Comparison of a) the data sets of the CORINE programme and official statistics, which are available for reconstruction of land use in 1990, and b) the data reconstructed for LULUCF reporting

Sources	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land
Data sets for comparison (areas in kha)						
CORINE	10,305.23	16,923.89	4,808.22	958.60	2,700.42	83.27
BOHE 1991		12,585.24	5,329.55			
FE 1992	10,435.57	19,543.25		780.09	4,702.57	245.23
Reconstruction (areas in kha)						
Previous	10,835.37	14,212.88	7,068.83	754.15	3,381.50	1.68
New	11,016.74	14,338.26	6,086.51	779.24	3,283.50	275.37

In addition to showing that no consistent data set is available for 1990 in Germany, Table 305 reveals that the result of the recalculation lies within the fluctuation range of the area data available for that period. Larger discrepancies occur only in the Settlements and Other Land categories. In the main, and as is the case for the other categories, the discrepancies are likely to be due to allocation problems and to differences in definitions of these categories. In addition, the data sources used for comparison are also subject to uncertainties (in some cases, major uncertainties), as a result of the survey algorithms used (for example, in the main soil-use survey, only operations with areas > 2 ha are included) and of technical issues (CORINE, survey scale and differentiation between grassland and cropland).

19.5.2.1.2 Determination of land-use changes, and of use-change-related area shifts

Since the IPCC reporting categories "Cropland", "Forest land", "Grassland", "Wetlands", "Settlements" and "Other Land" have no direct correspondences among the object types of the Basis-DLM, that system's ATKIS® categories have to be manually correlated with the IPCC reporting categories. In addition, new "IPCC shapefiles" have to be created, via GIS processing, that contain the polygons pursuant to the IPCC reporting categories (cf. Table 306). This was accomplished with the PostgreSQL database system, with PostGis. The necessary extensive GIS processing was controlled via scripts, of our own development, written in SQL. The GIS data sets were processed in a single calculation step, for all of

Germany. With this approach, all procedures for manipulating the relevant data records are transparent, consistent and comparable.

For the Submission 2011, a number of changes were made, with regard to allocation of object types to the individual land-use categories, that made it necessary to recalculate the entire data set through 1990. Table 306 shows allocation of ATKIS® object types to the IPCC land-use categories. In keeping with GPG (2003), the following object types have been reassigned to the following IPCC land-use categories: Category "4108 woods" has been shifted from "forest" and "other land" to "grassland"; and categories "4110 fallow land" and "4198 glades" have been shifted from "other land" to "settlements".

Table 306: Allocation of main object-type index numbers and attributes in ATKIS® to IPCC land-use categories

ATKIS Object-type catalog		
Object number	Object type	Description / attributes pursuant to ATKIS object-type catalog
IPCC category: Forest		
4107	Forest	Deciduous, coniferous and mixed forest
IPCC category: Cropland		
4101	Cropland	Area for cultivation of field crops (such as grain, legumes, root crops) and berries (such as strawberries)
4103	Horticultural land	Area for cultivation of vegetables, fruit and flowers, and for growing of cultivated plants
4109	Specialised cultivation	Area for cultivation of certain plants (such as hops, grapes, orchards).
IPCC category: Grassland		
4102	Grassland	Meadows, pastures, greenery along transport infrastructure
4104	Heath	
4108	Wood	Area covered with individual trees, groups of trees, bushes, hedges and shrubs.
IPCC category: Wetlands		
4105	Peat bogs and fens	Uncultivated area whose top layer consists of peaty or decomposed plant remains.
4106	Swamp and reed	Water-saturated area that is intermittently inundated.
2121	Mining plants	Only peat-extraction areas
5100	Waters	Such as dammed lakes, reservoirs, movable banks
IPCC category: Settlements		
2100-2135	Structurally modified areas	Contiguously built-up areas with sizes of at least 10 ha or with at least 10 properties.
2201	Sports facilities	Area with structures and facilities intended to be used for (competitive) sports and by spectators. Sports facilities include "stadiums", "sports areas" – such as football pitches, tennis courts, ice-skating rinks – "shooting ranges", "swimming pools", "outdoor swimming pools" and "golf courses".
2202	Recreational facilities	Area with structures and facilities intended for recreational purposes. Recreational facilities include "open-air theaters", "open-air museum", "swimming pools, outdoor swimming pools", "zoos", "amusement parks" "safari parks", "game enclosures" and "drive-in movie theatres" and "outdoor movie theatres".
2213	Cemetaries	
2227	Greenswards, parks	Large areas with trees, shrubs, grass areas, flower beds and/or paths, and that are intended primarily for recreation and as a means of urban beautification.
2228	Camping areas	
2300 – 2352	Buildings and other facilities	
3100 – 3205	Roads and railways	
3301	Airports	
3302	Airfields	
3400 – 3543	Ship-transport and related facilities	For example, ports, transmission masts, bridges, tunnels, piers
4110	Fallow land	Areas that for some time have not been used in accordance with their original purpose.
4198	Glades	
IPCC category: Other land		
4120	Areas without vegetation	Areas without significant vegetation cover, as a result of special soil characteristics such as unprotruding rocks, sand or ice areas.
4199	Area currently undefined	Areas whose characteristics cannot currently be determined, in terms of allocation to object types.

Via a range of complex calculations, each year's set of ATKIS® data was correlated with land uses within the IPCC-category framework (with the data still carrying the considerably more differentiated object-type key used by ATKIS®). The resulting polygonal data records were then linked with data records from the BÜK 1000 soil-survey map system, which is also georeferenced. This procedure makes it possible to correlate each land-use area with its pertinent soil association, including relevant characteristics.

For determination of land-use changes, these data were then intersected with the corresponding data – prepared in a similar manner – for the following year. The result of this step is a selection of all those areas on which land use differs between the initial year and the subsequent year, i.e. on which a land-use change has occurred. Table 307 shows the theoretically possible land-use changes and their allocation to the relevant IPCC categories and subcategories. In keeping with the relevant rules, land-use changes within the category "other land" are not included, since such land is, by definition, "unmanaged". In addition, land-use changes from "managed" to "unmanaged" lands are not permitted. Since ATKIS shows land-use changes to Other Land, in each land-use category a subcategory was introduced, under "category remains category", in which such land-use changes are recorded.

Table 307: Allocation of possible land-use changes to IPCC categories and subcategories

Cropland:	
Initial	Final
Cropland remaining Cropland	
4101/4103	4109
4109	4101/4103
4101/4103/4109	4120/4199
Forestland converted to cropland	
BWI	BWI (ratio 4101/4103/4109 adapted to BWI cropland area)
Grassland converted to cropland	
4102/4104/4108	4101/4103/4109
Wetlands converted to cropland	
4105/4106/2121/5100	4101/4103/4109
Settlements converted to cropland	
2100 - 3543/4110/4198	4101/4103/4109
Other land converted to cropland	
4120/4199	4101/4103/4109
Grassland	
Initial	Final
Grassland remaining Grassland	
4102/4104	
4108	4102/4104
4102/4104/4108	4120/4199
Forestland converted to grassland	
BWI	BWI (ratio 4102/4104/4108 adapted to BWI grassland area)
Cropland converted to grassland	
4101/4103/4109	4102/4104/4108
Wetlands converted to grassland	
4105/4106/2121/5100	4102/4104/4108
Settlements converted to grassland	
2100 - 3543/4110/4198	4102/4104/4108
Other land converted to grassland	
4120/4199	4102/4104/4108
Wetlands	
Initial	Final
Wetlands remaining Wetlands	
4105/4106/5100	2121
2121	4105/4106/5100
2121/5100	4105/4106
4105/4106	2121/5100
5100	4105/4106/2121
4105/4106/2121	5100
Forestland converted to wetlands	
BWI	BWI (ratio 4105/4106/2121/5100 adapted to BWI wetlands area)
Cropland converted to wetlands	
4101/4103/4109	4105/4106/2121/5100
Grassland converted to wetlands	
4102/4104/4108	4105/4106/2121/5100
Settlements converted to wetlands	
2100 - 3543/4110/4198	4105/4106/2121/5100
Other land converted to wetlands	
4120/4199	4105/4106/2121/5100
Settlements	
Initial	Final

Settlements remaining settlements	
2100-2135	2201 – 3543 / 4110/4198
2201	2100 – 2135 / 2202 – 3543 / 4110 / 4198
2202	2100 – 2135 / 2201 / 2213 – 3543 / 4110 / 4198
2213	2100 – 2202 / 2227 – 3543 / 4110 / 4198
2227	2100 – 2213 / 2228 – 3543 / 4110 / 4198
2228	2100 – 2227 / 2230 – 3543 / 4110 / 4198
2300 – 2352	2100 – 2228 / 3100 – 3543 / 4110 / 4198
3100 - 3205	2100 – 2352 / 3301 - 3543 / 4110 / 4198
3301	2100 – 3205 / 3302 - 3543 / 4110 / 4198
3302	2100 – 3205 / 3301 / 3400- 3543 / 4110 / 4198
3400 – 3543	2100 – 3302 / 4110 / 4198
4110	2201 – 3543 / 4198
4198	2201 – 3543 / 4110
Forestland converted to settlements	
BWI	BWI (ratio 2100 – 3543/4110/4198 adapted to BWI settlements area)
Cropland converted to settlements	
4101/4103/4109	2100 – 3543/4110/4198
Wetlands converted to settlements	
4105/4106/2121/5100	2100 – 3543/4110/4198
Grassland converted to settlements	
4102/4104/4108	2100 – 3543/4110/4198
Other land converted to settlements	
4120/4199	2100 – 3543/4110/4198
Other lands	
4120	Area without vegetation
4199	Area undefined

For the years 2006, 2007, 2008 and 2009, land use and land-use changes were determined on an annual basis. As a result of data-availability constraints, the period 2000 – 2005 had to be processed in combined form.

Via intersection of land-use maps and the soil map, carbon emissions and storage were derived from the changes in carbon stocks in the thus-identified mineral soils, as well as via data on any need for grouping with organic soils, as obtained via main-soil associations.

Here as well, the necessary calculations and correlations were carried out with the help of task-dedicated programme scripts of our own development, in the interest of minimising manipulation errors and of ensuring the transparency and comparability of all results. As a final step, the results were then combined within the Excel format, for transmission to the Central System of Emissions (CSE).

19.5.2.1.3 Areas of organic soils

The areas and distribution of organic soils were shown via the 1:1,000,000-scale soil-survey map (BUEK 1000), with georeferencing. Main-soil associations 6 and 7 – primarily fens and raised bogs – were chosen. Pursuant to the German soil-science mapping instructions (deutsche Bodenkundliche Kartieranleitung; Arbeitsgruppe Boden 2005), such associations were defined as peat soils with organic-substance fractions > 30 mass-% and a thickness > 30 cm. This listing procedure is inadequate, since the IPCC definition for organic soils is oriented to the relevant WRB definition (FAO, 1998), which is considerably broader than the German terminology for organic soils pursuant to the "KA 5" mapping instructions (Arbeitsgruppe Boden (working group on soils) 2005). On the other hand, the main-soil associations 6 and 7 also contain fractions of mineral soils – known as "associations" (Begleitgesellschaften). As a result, the total area of organic soils is mapped more precisely

than is the spatial distribution of such soils. Due to a lack of the necessary suitable digital and analog soil maps, it is currently not possible to identify Germany's organic soils precisely, in keeping with the relevant IPCC definition. The listing of the country's organic soils may thus be incomplete. The "organic soils" project is expected to remedy this situation by 2013 and produce a 1:200,000-scale, georeferenced map, in keeping with the IPCC definition, of Germany's organic soils.

For the years 2000 – 2009, georeferenced allocation of land use to organic-soil areas was carried out via intersection of the areas of main-soil associations 6 and 7, from the BÜK 1000 soil map, with the ATKIS® data on land use for each relevant year. Allocations for the years 1990 through 1999 were carried out in proportion to organic-soil areas' shares of land-use changes in the period 2000 – 2005.

19.5.2.2 Determination of carbon stocks, and of their changes as a result of land-use changes

Data on spatial distribution of soil communities in Germany is available in the form of a digital soil map on a scale of 1: 1,000,000 (BUEK 1000). The soil map has been prepared via proportionate allocation of discrete profile data (obtained at individual points in the landscape) on land units (polygons) within the map area. The profiles provide quantitative information on a range of key factors measured. Such information provided the basis for estimating the carbon stocks in agricultural soils. Calculation was carried out using the map's/legend's data for the lead profiles of the 71 main-soil units, data that included specific C_{org} content measurements, humus, raw-density and skeleton classes and profile and horizon descriptions. With this data, and under the assumption that the map's values, in each case, are representative of the entire relevant legend/map unit, C_{org} stocks were calculated. To this end, the C_{org} content figures were multiplied by the relevant raw densities and horizon depths and the relevant skeleton portions were deducted. The horizon stocks were added to a depth of 30 cm. The range of carbon stocks was determined via the figures in the relevant legend/map unit pursuant to the KA 4 mapping instructions (ARBEITSGRUPPE BODEN, 1994). In each case, the aforementioned algorithm was used to calculate a minimum value (lowest possible C_{ORG} content for the class, lowest possible storage density, maximum skeleton content) and a maximum value (highest possible C_{ORG} content for the class, highest possible storage density, minimum skeleton content). The range obtained in this manner is the measure for the potential spreading of results.

A geo-information system (GIS) was used to assign the individual soil units to the individual polygons of the relevant land-use units. The BUEK 1000 survey map was overlaid with polygons of district boundaries, as well as with the ATKIS® and CORINE-Landcover data records. For each of the thus-resulting polygons, carbon stocks to a depth of 30 cm were then calculated.

19.5.2.3 Changes in carbon stocks in the soil and in biomass

19.5.2.3.1 Derivation of EF for mineral soil as a result of land-use changes

The emission factors for changes in carbon stocks in the soil, resulting from use changes, were drawn from the literature. To this end, a number of studies, including several reviews, were evaluated. From these studies, those studies were selected that directly considered carbon stocks following land-use changes, or whose data permitted relevant derivation. Of

these studies, in turn, only those were used for EF derivation that apply criteria, for soil, climate and other parameters (for example, soil depth of about 30cm) that are at least somewhat comparable to those required for German reporting (ANKEN et al., 2004; BLANK & FORSBERG, 1989; BOUMA & HOLE 1971; BOWMAN et al., 1990; BURKE et al., 1995; BUYANOVSKY et al., 1987; CAMBARDELLA & ELLIOT., 1992 & 1993; CAMPBELL et al., 1989; CHAN AND MEAD, 1988; CONANT et al., 2001; DAVIDSON & ACKERMANN, 1993; DEGRYZE et al., 2004; FRANZLUEBBERS et al., 1999; FRANZLUEBBERS et al., 2000; GEBHART et al., 1994; GUO & GIFFORD, 2002; HART et al., 1988; HORNE et al., 1992; IHORI et al., 1995; JASTROW & LUSSENHOP, 1998; LARIONOVA et al., 2003; LAWS & EVANS, 1949; LIEBIG et al., 2004; MANN, 1986; MARTENS et al., 2003; MURTY et al., 2002; POST & KWON, 2000; POTTER et al., 1999; REEDER et al., 1998; ROSS AND HUGHES, 1985; SKEMSTAD et al., 1994; TIESSEN et al., 1982; VORNEY et al., 1981 etc.).

In spite of the wide distribution of absolute results it shows, the literature review supports the oft-heard assumption that conversion of grassland to cropland leads to losses of soil carbon stocks, and that conversion of cropland to grassland enriches soil carbon stocks. Nonetheless, results can be adduced that support the opposite assumption. The breadth of the spectrum of results complicates evaluation, although very close relationships can be found via simple or multiple regression ($r^2 > 0.9$). The results that are produced in this manner, however, show little plausibility and always include 0 within their 95 % confidence intervals.

The review produced the national emission factors listed in Table 308, factors which represent the total changes in soil carbon. Those factors are applied fully only for the year of conversion, and only for that part of the Framework Convention. The reasons for this are as follows:

1. Subject-specific reasons: The results of the aforementioned review, and those of POEPLAU et al. (2011), show that the periods for transition from one land-use type to another differ, depending on the final use involved. For example, 20 years would be too long for a land-use change to cropland, and too short for conversion of cropland to grassland. Overall, the system is highly asymmetric, and the relevant results are subject to large uncertainties with regard to the directions of carbon-stock changes and the transition periods involved.
2. Technical reasons: Tracing of carbon-stock changes on many millions of individual areas, over a period of 20 years, necessitates unreasonably large expenses and effort in terms of the involved IT systems, data storage and data management

Table 308: Percentage carbon-stock changes in the first year following land-use changes

Initial\Final	Forest	Crop _{an.}	Crop _{peran.}	Grass	Wetland	Settle- ment	Other Land
Forest		-30.43	-15.21	k.V.	15.56	k.V.	k.V.
Crop _{an.}	15.56		7.78	15.56	15.56	k.V.	k.V.
Crop _{peran.}	7.78	-15.21		7.78	15.56	k.V.	k.V.
Grass	k.V.	-30.43	-15.21		15.56	k.V.	k.V.
Wetland	k.V.	-30.43	-15.21	k.V.		k.V.	k.V.
Settlement	k.V.	-30.43	-15.21	k.V.	15.56		k.V.
Other Land	k.V.	-30.43	-15.21	k.V.	k.V.	k.V.	

k.V.: no change (keine Veränderung); an.: annual; peran.: perennial

A programme script is used to allocate these factors to land-use-change areas, and to calculate the relevant changes in carbon stocks. The script calculates the changes in soil-carbon stocks for each change polygon – and for each type of land-use change, with the "before" and "after" land uses coded via the ATKIS® object-type key. The "before and after" carbon-stock changes resulting for individual polygons, via subtraction, are then summed at the national level – again, for each type of land-use change. They are then assigned to the relevant reporting categories pursuant to CRF and listed as the sums to be reported for the pertinent categories. This procedure ensures that the data are handled in a consistent manner over the years – i.e. it assures data transparency, consistency and comparability.

19.5.2.3.2 Derivation of calculation figures (emission factors) for biomass

19.5.2.3.2.1 Forest, permanent cultivations, wetlands and groves within settled areas

In each case, carbon stocks in forest biomass were estimated on the basis of the mean value, for "forest land converted to other land", as determined for Germany in the National Forest Inventory, for the relevant report year. (With regard to the relevant methods and derivation, cf. Chapters 7.2.4.1 and 11.3.1.1).

Table 309: Mean carbon stocks in forest biomass of "forest land converted to other land" areas, for the relevant report years (the value consists of the sum of above-ground and below-ground biomass and dead wood and litter)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
[Mg C/ha]	59.516	59.404	59.291	59.179	59.066	58.954	58.841	58.729	58.616	58.504
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
[Mg C/ha]	58.391	58.279	55.941	55.828	55.716	55.603	55.491	55.378	55.266	55.153

For woody permanent cultivations (such as vineyards and orchards), and for woody plants within settled areas, the IPCC default factor (63 t/ha; GPG-LULUCF 2003) was used. Carbon stocks in biomass of wetlands were defined as 30 t/ha, on the basis of expert judgement.

19.5.2.3.2.2 Grassland and non-perennial crops:

Emission factors for carbon stocks in above-ground biomass of grassland and non-perennial crops were derived on the basis of results of the 1999 main survey of soil use (Bodennutzungshaupterhebung), of harvest estimates and of figures from the literature. The calculation was carried out at the district level for wheat, rye, winter barley, summer barley, oats, triticale, silo corn, fodder plants (clover, lucerne, lupin, grass), potatoes, sugar beets and cash crops (primarily rape). The figures for the areas under cultivation with the various relevant crops (ha), and those for harvest yields (t/ha), were taken from the 1999, 2003 and 2007 main surveys of soil use (Bodennutzungshaupterhebungen) and from harvest surveys for the period 2000 – 2008 (*Federal Statistical Office*). Here and there, some figures were lacking for harvest yields in individual districts; in such cases, average annual values were used instead. For the relevant Länder (states), such values were obtained from the relevant tables in official Länder statistics; for Germany as a whole, they were obtained from the Statistical Yearbook (Statistisches Jahrbuch; BMVEL, 2003, 2007). In each case, the biomass, in t/district, was obtained by multiplying the area under cultivation by the applicable harvests. The harvest figures given by the main survey of soil uses (BOHE) were adjusted to take account of residual moisture content. For grain, a residual moisture content of 14 % was assumed. The corresponding figures for other crops were as follows: silo corn, 28 %; potatoes, 78 %; and sugar beets, 77 %.

Biomass of straw, leaves and crop parts, and of roots, was calculated from harvest yields with the help of suitable factors (straw: straw / grain ratios; roots: root-stubble / grain ratios) as well as of suitably dimensioned size data (Table 310).

Table 310: Factors and dimensioned size data for determining total biomass of plants from harvests

	Straw	Leaves / crop parts	Roots
Wheat	1.2		0.24
Rye	1.7		0.34
Winter barley	1.05		0.32
Spring barley	1.05		0.21
Oats	1.4		0.35
Feed plants			4.22
Triticale	1.7		0.30
Rape	1.9		0.40
Silo corn	1		0.06
Potatoes		0.4 t/ha	0.11
Sugar beets		0.8 t/ha	0.06

Sources: Die Landwirtschaft 1998; FISCHER 1988; OEHMICHEN 1990; RUHR-STICKSTOFF AG 1985

Grassland biomass is determined on the basis of annual harvest yields for the relevant Länder. It was assumed that harvesting/mowing takes place three times annually. For determination of total biomass, harvest yields were divided by three (to take account of thrice-annual mowing). The resulting quotients were then multiplied by a factor of 4.2, since underground plant parts account for about 80 % of grasses' total biomass. The sum of the so-resulting value and the pertinent grassland yield represents the total "grassland" biomass per area unit.

For calculation of biomass carbon stocks, average carbon stocks of 45 % were assumed (carbon content of individual plant parts and types, 37 – 60 %; whole plants, 44 – 48 % (OSOWSKI et al., 2004)). The sum of all parameters yields the carbon stocks for total biomass of agricultural land, at the district level. For individual areas, ATKIS® shows only uses, and not specific crops cultivated. For this reason, district-specific, average, biomass carbon-stock values (in t/ha) had to be determined. For each year, those values are then used, as $EF_{initial}$, as a basis for all further calculations in connection with land-use changes for the year. In each case, the district-specific value was determined by dividing the district's total biomass stocks by its cropland area. Biomass calculations were carried out pursuant to IPCC GPG LULUCF (2003), with the help of a programme script developed for that purpose. The programme assigns biomass factors, before and after the land-use changes, to the relevant polygons, and in keeping with the pertinent usage keys; calculates the biomass carbon stocks before (decrease) and after (increase) the use changes; forms the pertinent differences; sums the results at the national level, for the different types of land-use changes; and outputs the results in the relevant CRF categories. This approach ensures the transparency, consistency and comparability of all results over the years.

The minimum and maximum values for carbon stocks in biomass of land in different land-use types are listed in Table 311. Each year 15 different factor classes are formed that, following regional subdivision, consist of up to 439 dimensioned factors (one factor for each land-use category, for each administrative district, for cropland and grassland). Those classes are assigned to the relevant land-use categories as shown in Table 312.

Table 311: Factor classes, and minimum and maximum values, for dimensioned factors (t C ha^{-1}) for determination of carbon stocks in biomass, 1990 – 2009

Factor class	Minimum and maximum value, 1990 – 2009; factor in t C ha^{-1}	Remarks
EF 1	55.13 – 59.51 t C ha^{-1}	BWI average
EF 2	2.25 – 28.2 t C ha^{-1}	District-specific, weighted values (per year: $n = 439$)
EF 3	50 % EF 2 + EF 5	Expert judgement
EF 4	2.8 – 11.83 t C ha^{-1}	Länder-specific average values (per year: $n = 13$)
EF 5	63 t C ha^{-1}	IPCC default
EF 6	30 t C ha^{-1}	Expert judgement
EF 7	10 % EF 2 + 40 % EF 5	Expert judgement
EF 8	30 % EF 2 + 50 % EF 5	Expert judgement
EF 9	40 % EF 2 + 10 % EF 5	Expert judgement
EF 10	50 % EF 2 + 20 % EF 5	Expert judgement
EF 11	20 % EF 2 + 40 % EF 5	Expert judgement
EF 12	20 % EF 2 + 30 % EF 5	Expert judgement
EF 13	40 % EF 2	Expert judgement
EF 14	70 % EF 2	Expert judgement
EF 15	20 % EF 2 + 20 % EF 5	Expert judgement

Table 312: Allocation of emission factor classes for biomass to the ATKIS object types combined with IPCC land-use categories

ATKIS Object Type Catalogue			
Object	Object type	Description/Attributes compendiously	eEF-
Forest land			
4107	Forest	Deciduous, coniferous and mixed forests	EF 1
Cropland:			
4101	Cropland	Area for the cultivation of field crops	EF 2
4103	Horticultural land	Area for the cultivation of vegetables, fruits and flowers (no gardens)	EF 2
4109	Specialized cultivation	Vineyards, orchards, hops fields, tree nurseries.	EF 3
Grassland			
4102	Grassland	Meadows, pastures, roadside greenery	EF 4
4104	Heath		EF 4
4108	Wood	Area with shrubs, single trees, groups of trees, hedges and hedgerows (which are not falling under the forest definition)	EF 5
Wetlands			
4105	Peat bogs and fens	Area with peat soils	EF 6
4106	Swamp and reed	Area, which is water saturated and temporarily inundated	EF 6
2121	Mining plant	Area for peat extraction	/
5100	Waters	Lakes, water reservoir, ponds	/
Settlements			
2100-2135	Structurally modified areas	mainly residential areas and industries	EF 15
2201	Sports facilities		EF 10
2202	Recreational facilities		EF 11
2213	Cemetaries		EF 9
2227	Greenswards/parks		EF 8
2228	Camping areas		EF 12
2300 – 2352	Buildings and other facilities		/
3100 – 3205	Roads and railways		/
3301	Airports		EF 13
3302	Airfields		EF 14
3400 – 3543	Ship-transport infrastructure and related facilities		/
4110	Fallow land	Area not used for original purpose for a longer time	/
4198	Glades		/
Other lands			
4120	Area without vegetation		/
4199	Area undefined		/

19.5.2.4 Liming

Emissions from liming are calculated from the total quantities of lime fertiliser applied. Fertiliser lime includes all carbonates of calcium and magnesium, either as pure substances or as additives. Reporting thus covers emissions from dissolving of calcium carbonate, mixed carbonates, carbonated lime, residual lime and calcium ammonium nitrate.

The quantities of lime applied are derived from the product quantities sold within the country, under the assumption that lime fertiliser is applied in the year in which it is sold. The product-quantity figures are taken from official statistics (*FEDERAL STATISTICAL OFFICE*, Fachserie 4, Reihe 8.2). Because companies have a statutory obligation to supply information, the data collection is complete. The data do not provide direct information on the annual use of fertilisers in agriculture and forestry. For this reason, figures cannot be differentiated with regard to types of application (dolomite or lime) or to the application sites. They list solely the "fertiliser quantity", the total quantity of lime sold to the forestry sector.

Differences can occur between amounts sold and amounts actually applied

- As a result of changes in vendors' stocks
- Due to use of fertiliser outside of agriculture and forestry, e.g. on private land, gardens, sports facilities.

In fertiliser statistics, all lime-containing fertilisers, including magnesium carbonates, are reported as CaO. The relevant CO₂ emissions are derived from such statistics stoichiometrically.

In calcium ammonium nitrate, the nitrogen fraction is assumed to account for 27 %. As a result, ammonium nitrate accounts for 77.1 % and calcium carbonate accounts for 22.9 %. Here as well, the CO₂ emissions are determined stoichiometrically.

19.5.2.5 Determination of N₂O emissions following conversion to cropland

N₂O emissions, following conversion of other use forms to cropland, were determined pursuant to IPCC-GPG (2003). To that end, the carbon-stock changes determined for the various individual polygons were divided by the C/N ratios for the pertinent soils, to obtain the changes in nitrogen stocks. The resulting changes were then combined with the default value of 0.0125 t N₂O-N/t N; this yielded the relevant N₂O emissions.

19.5.2.6 Planned improvements

At the same time, although the approach selected for the present submission is spatially and chronologically consistent, it is still only an interim solution. Germany plans to convert its LULUC reporting system in the next two years, with a view to:

- Standardisation
- Prevention of the artifacts that can occur via mixing of different approaches
- Obtaining a maximally precise, standardised description of the entire report period, especially for the years 1990 – 2000
- Establishment of complete consistency between KP and UNFCCC reporting
- Simplification

Plans call for complete conversion of the German LULUCF reporting system to a point-raster system. In an approach similar to that used for the forestry system, a sampling procedure is to be developed and implemented, taking account of all existing data records, for areas outside of forest land.

This conversion will include the following improvements:

1. Changes in the system for reporting emissions from mineral soils
 - Derivation of typical, use-dependent carbon stocks in mineral soils, weighted by soil type and area, for all of Germany
 - Development of a new system for describing carbon-stock changes as a function of land use
2. New emission factors, differentiated by soil type and soil use, for organic soils
3. Change in the system for determining carbon-stock changes in biomass
 - Reduction in the total number of emission factors, via calculation of area-weighted mean values for all of Germany
 - An increase, over the number used to date, in the number of plant species that enter into area-weighted mean values

- Separate calculation of carbon stocks for above-ground and below-ground biomass
 - New country-specific default factors for carbon stocks in wood plantations outside of forests (NIR 2012/2013)
4. Complete, GPG-conformal uncertainties calculation
 5. Improvement of the QA/QC concept (cf. the answer to ERT: Action plan for resolving issues identified by the ERT regarding KP LULUCF).

In addition to these improvements, which will be implemented in the next report, a range of projects are currently underway, with the aim of obtaining, within the next three years, the best-possible country-specific emission factors and activity data as a basis for LULUCF reporting.

19.5.2.7 Action plan for resolving issues identified by the ERT regarding KP LULUCF

The following section presents the original wording of the action plan that, in the framework of the in-country review, Germany was requested to provide. In its action plan, Germany was to explain its plans for eliminating, as quickly as possible, the LULUCF-sector issues identified during the review.

Numerous points of the relevant plan have already been implemented in the present NIR 2011. For those measures not yet implemented, especially the reconstruction of land use in 1990 and conversion of the reporting system, relative to areas outside of forest-related lands, from a wall-to-wall approach to a sampling approach, a tight schedule is in place (cf. the schedule below). That schedule will ensure that the remaining measures are implemented within the short term. The schedule calls for an international workshop to be held in May 2011 at which the new LULUCF and KP-LULUCF climate-reporting system will be presented to the UN Climate Secretariat and to national and international experts. The discussion of methods, data sources and quality assurance / quality control systems that will take place at that event is expected to ensure that the action plan is completely implemented and verified within the meaning of the requirements of the Expert Review Teams. The wording of the action plan is as follows:

The ERT requested Germany to present an action plan to

1. Describe the system for the preparation of the estimates (land area identification including the provision of the land use matrix, aggregation of sub-land use categories of ATKIS to be consistent with the sub-categories mentioned in the IPCC good practice guidance for LULUCF and definition and also methodological issues related to the estimation of emissions and removals, in particular of soil carbon);
2. How consistency across categories and time series will be ensured; and
3. QA/QC measures (plan, implementation).

In response to the recommendations by the ERT the parts related to LULUCF and KP- LULUCF in the "Konzept zur Erstellung von Emissions-Inventaren und Kohlenstoff- Inventaren im nachgeordneten Bereich des BMELV" ("Concept for the creation of emission and carbon inventories in the subordinate range of the BMELV") have been updated and extended to incorporate all recommendations of the ERT. The text parts have been agreed between the vTI team and BMELV and are under discussion

with UBA. The action plan describes the key steps to be taken and their implementation in the next one to two years as well as steps already implemented in the submission 2011.

1. System for preparing the estimates

KP-LULUCF

1. Consistency between CRF and KP-LULUCF: The system used for preparing the estimates for KP-LULUCF in the submission 2011 is being used as template for the estimates for LULUCF under the UNFCCC (cf. UNFCCC-LULUCF).
2. A consistent land-use matrix for the old and new Länder for the period in which no common data basis for forestry is available (1990-2002) is being prepared for NIR 2012 (cf. UNFCCC-LULUCF): Therefore, land use and land-use changes for the areas currently derived from GSE-FM, including all available data sources (GSE-FM, NFI, aerial photographs), will be analysed on the NFI raster, especially for areas from 0.1 to 0.5 ha size. Thus the detection system for those areas will be converted to the sampling system to ensure the best possible spatial and temporal consistency of the land use matrix.

UNFCCC-LULUCF land identification

At the recommendation of the ERT, more precise analyses were carried out of CORINE and ATKIS (BASIS-DLM) data to provide a basis for showing non-forest land uses for the period 1990 through 2000. Those analyses revealed that it is not possible to produce a consistent land-use matrix and time series, for the period until 2000, by combining CORINE and ATKIS[®].

The CORINE land-use map is not consistent with the land-use map of ATKIS. It will thus be necessary to carry out a new, consistent reconstruction of land use for years prior to 2000 (cf. NIELAND 2009 – for example, p.87).

The purpose of the ATKIS data is to provide a maximally current, high-resolution landscape model (land cover) of Germany, with regularly updated and expanded geometries and content. Additional updating is planned for the coming years. This differs from the purpose of emission reporting, in which time-series consistency in geometries and attributes is crucial. vTI-AK has thus decided that ATKIS data used in polygon-based GIS mode may not be in full accordance with the requirements of the IPCC Guidelines and Good Practice Guidance because artifacts from updating geometries and attributes cannot be easily distinguished from real land-use changes. Since vTI-AK is the only user of ATKIS, to date, for national wall-to-wall mapping of land-use time series, the additional efforts needed to make the GIS-based approach for land identification fit to the reporting requirements would be unreasonable.

vTI decided to move to a point-raster approach for land identification in all land categories, which is compatible with the approach already taken for the forestry related categories and for KP-LULUCF reporting. The harmonized approach will make it much easier to arrive at a consistent land identification, the construction of a consistent land use matrix and a consistent time series. It further allows the comparison with alternative external data sources, e.g. from the European LUCAS grid, with agricultural statistics, aerial photography, etc.

In general, the switch to a system of detection of land use and land-use changes with the use information derived from a plot grid will ensure consistency over time and space. In addition, it will

make it possible to estimate uncertainties, with respect to the land-use matrix, with statistical procedures. Such estimation will thus be an integral part of the system.

Implementation of land identification for non-forest lands

Tests to be performed as a basis to design an adequate point raster approach, based on ATKIS and additional data sources, that does not lead to over- or underestimation of C stock changes:

1. Identification of "hotspots" and areas with special characteristics and currentness (soil types with high organic carbon stocks, land-use categories with high specific biomass C stocks, areas with short-term and frequent land-use changes), for designation of areas on which the density of the point raster needs to be increased with respect to the average raster.
2. Identification of the typical size and frequency of area changes to determine the minimum significant units of land use change that the average point raster density has to be able to identify.
3. Consistency with NFI raster and approach, for purposes of identifying afforestation and deforestation for KP-LULUCF
 - a. Determination of the minimum number of sampling points; possibly, stratification and distribution of sampling points
 - b. Review of consistency with current methods: the time series of land-use matrices of 2000 – 2010 have to be comparable, and any differences have to be explained (for example, artifacts in ATKIS).

Reconstruction of a consistent land-use matrix for 1990:

Adaption of CORINE 1990 by use of multiple data sets (CORINE 2000, 2006; ATKIS; statistical data e.g. "Bodennutzungshaupterhebung" and "Flächenerhebung"; Orthophotos) and via GIS and geostatistical methods; points of the raster which are approved by at least two data sets will be classified as verified. Additional data sources from CIR aerial photography and orthophotos will be used to verify ambiguous raster points and for validation.

Consistency between sub-land use categories of ATKIS and the sub-categories mentioned in the IPCC Good Practice Guidance

To show the consistency of the aggregation of sub-land use categories of ATKIS with the sub-categories mentioned in the IPCC Good Practice Guidance would go beyond the scope of this paper. A comprehensive table showing how these land-use categories are linked is provided in the Submission 2011.

Soil carbon

Following the recommendations of the ERT, Germany plans to change the methodology for estimating changes in soil organic carbon of mineral soils to a symmetric approach. In that approach, each land-use sub-category is represented by a typical soil organic carbon stock, calculated as the area-weighted mean per land-use sub-category, based on ATKIS land areas and the soil map BÜK 1000. Specific soil organic carbon stocks per land-use sub-category are calculated from such typical values with the help of the IPCC's (2003) "relative factors for carbon-stock changes as a function of use, on the basis of typical values for conversion of "native" soil organic matter stocks (forest, grassland, wetland, settlement) to cropland sub-categories. This approach will be further refined by national data for soil organic carbon stocks once the nation-wide soil inventory results become available.

2. Consistency in land-area designation of and time series

Reconstruction of consistent time series for land-use changes

With the change to the point raster and the reconstruction of a consistent land use matrix for 1990, consistency across land-use categories and time series is assured for the net land-use changes, for the entire report period since 1990 (cf. Chapter 1).

To reach full consistency, the gross land-use change has to be reconstructed for the years 1990 – 2000. On the basis of land-use-change matrices from point rasters versus “Bodennutzungshaupterhebung” and other data sources, typical fractions of gross land-use change versus net land-use change will be developed.

3. QC/QA measures

The following additional QC/QA measures have already been agreed on:

1. The role concept and responsibilities have been clarified in line with the QA/QC requirements of UBA. This includes the roles of BMELV and UBA.
2. The interfaces between responsibilities, and between sub-categories, and the data flows between institutions, have been agreed on and precisely described (cf. also Figure 1).
3. Hierarchical consistency checks of AD, EFs and IEFs, between CRFs and KP- LULUCF, and between NIR text and tables have been introduced, with specific additional responsibilities and assignments at each level so that a four-eyes principle is implemented for each and every part of the inventory.
 - a. The Web-based system for documentation and preparation of the NIR ("GG-Wiki"/"THG-Wiki"), which has been developed and used for the forestry parts of the LULUCF reporting, is being extended for use by all LULUCF and KP-LULUCF members for the submission 2012 (at the latest). This includes:
 - b. Full preparation of the NIR texts by work in one joint document with options for commenting and documentation of discussions on the text and calculations
 - c. A searchable documentation table of inventory-related activities, changes and updates with task assignments, deadlines and control functions (e.g. electronic ticketing system) and links to relevant documents
 - d. A calendar of inventory-related events (including information on contents, participants, documentation and a summary of results)
 - e. A file system with all relevant data exchanged between the participating institutes (vTI-WOI and vTI-AK).
 - f. Minutes of meetings and teleconferences
4. Communication and the flow of information among the LULUCF reporting team will be improved by (at least) monthly teleconferences, held to guarantee regular exchanges of findings and status of activities (results to be documented in the GG-Wiki).
5. Procedures for QA/QC of data sources and calculations have been described in greater detail than in the past. All relevant problems, measures, intermediate results and findings will be documented in the GG-Wiki.

6. No data redundancy. This will minimise inconsistencies and errors resulting from data transfer. Data holders will be identified in the GG-Wiki.
7. Data transfer from the final tables of vTI into CSE and CRF tables will be double-checked by persons responsible for calculations, and persons responsible for quality control, at both vTI and UBA. The results will be documented in the Wiki.
8. In co-operation with UBA, vTI is reviewing the possibility for using the CRF-Reporter software for data analysis, for facilitating consistency checks of time series, AD, EFs und IEFs, and for reviewing recalculations.

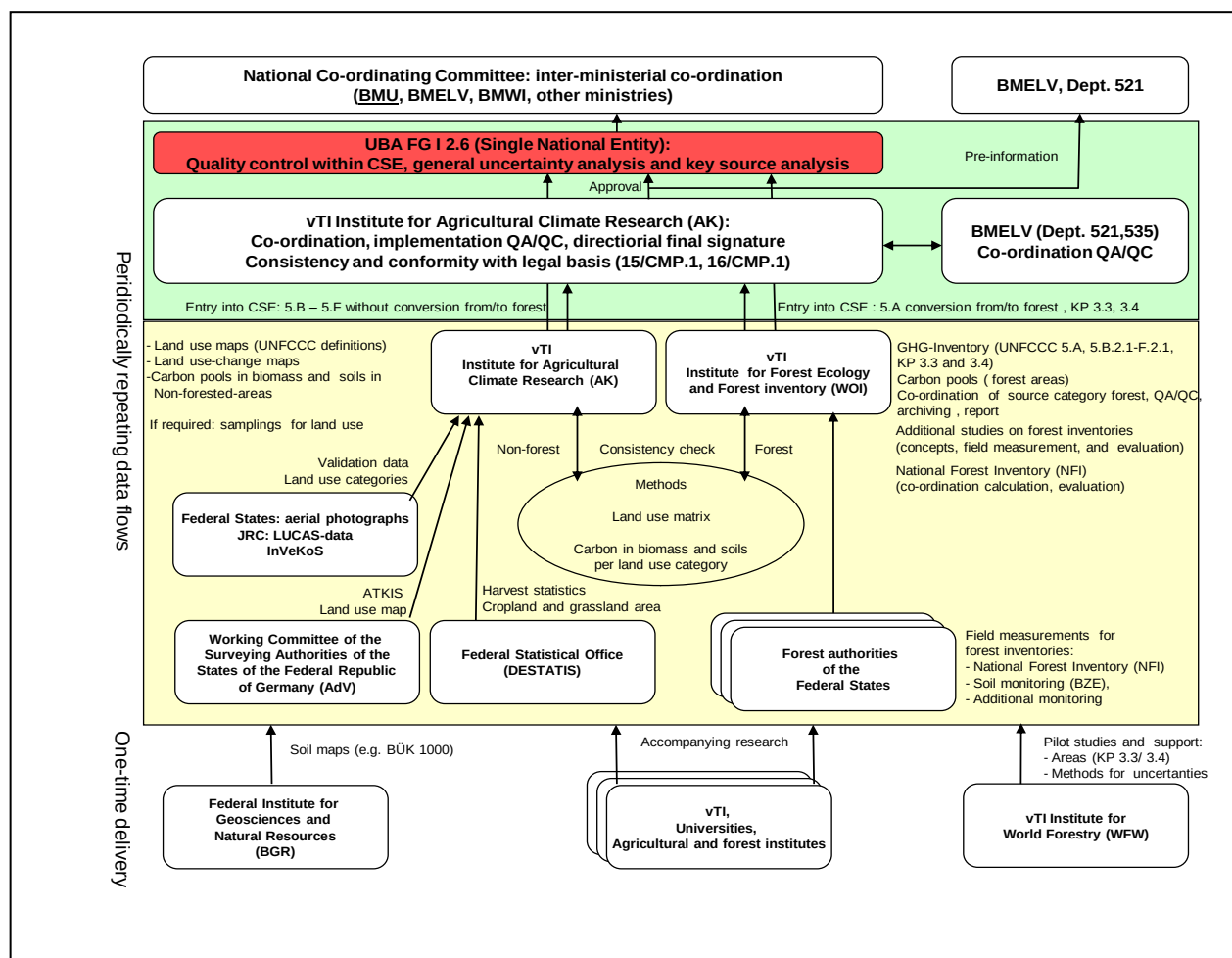


Figure 67: Responsibilities at, and data flows between, the institutions involved in preparing the submissions for LULUCF and KP-LULUCF. UBA manages final co-ordination on NIR and reporting tables ("departmental co-ordination") following completion of the CSE draft, the CRF tables and the NIR draft. That procedure is not included in the figure.

4. Implementation in the Submission 2011

System for preparing the estimates

The category Other Land has been re-defined and re-calculated so that only unmanaged land is included. This also ensures that no afforestation/reforestation or forest-management measures are correlated with unmanaged land. The forest-based area estimations for the new German Länder have been reviewed, and calculations errors have been corrected.

The CORINE data sets have been excluded from the calculations due to major inconsistencies with ATKIS. The time series of land use changes have been back-extrapolated to 1990. The approaches for biomass and soil have not been changed. A number of calculation errors have been corrected (i.e. IEF for organic soils for land conversion to FL, biomass stocks before/after land use conversions from/to FL and emissions by liming).

Consistent time series

A consistent land use matrix and time series have been constructed for the submission 2011 based on the following criteria:

- The sum of all land categories must match the constant land area. The constant land area has been defined as the area of Germany in ATKIS (in the administrative-boundary data set) in the year 2005.
- All data in connection with FL remaining FL and all conversions from and to forest are taken from the NFI (BWI). All other land-area data and conversion data are taken from ATKIS and recalculations. Review has been carried out to ensure that the area data lie within the uncertainties for the ATKIS land categories.
- FL, CL, GL, WL and S cannot be converted to OL, because a managed land category cannot be converted into unmanaged land.
- A comprehensive table of the land-use categories of ATKIS and their links to the categories mentioned by IPCC is provided.

QA/QC measures

The roles and responsibilities as described in the updated concept have been fully implemented. The GG-Wiki (THG-Wiki) has been used by vTI-WOI, but not yet by vTI-AK. QC of the data sources is in progress and has already led to the exclusion of the CORINE data sets due to major inconsistencies with ATKIS (cf. land identification). QC of calculations and of the NIR text (as described in the updated concept) have been implemented in most cases. QC is being further intensified, e.g. by participation in the IPCC Expert Meetings, the UNFCCC Workshop on the 2006 Guidelines, and a JRC technical workshop on LULUCF reporting under the Kyoto Protocol. In addition, a detailed analysis of the Swiss inventory methodology and data is planned by the end of 2010.

Table 313: Schedule for implementation of recommendations from the in-country review in emissions reporting in the areas of LULUCF and KP-LULUCF

LULUCF	
Land-use matrix	
2011	Methodological changes, clarification of the combination of the forest / LULUC point rasters
2011	Test calculations
2011	Land-use matrix by sub-categories
2011	International workshop for review and decision relative to the resolution of the point raster, to the choice of methods for non-forest soils and biomass and, possibly, to the methods for reconstruction of land use in 1990
2011	Recalculation of data for the period 2009 – 2005
Land use 1990	
2011	Concept for reconstruction of land use (all land uses, including forest) on the point raster for 1990, on the basis of CIR data and a statistical correction of CORINE
2012	Outsourcing of the contract. Tendering procedures at BLE typically last 4-5 months
2013	Final results of the outsourced contract
LULUC biomass	
2011	Detailed documentation of the calculations basis and of the steps taken, with the new procedure, for each sub-category; decisions on how to handle "wood"
LULUC soil	
2011	Detailed documentation of the basis for calculations and of the steps taken with the new procedure; decision on the relevant method
QA/QC	
Implemented	Joint work in the THG-Wiki (GG-Wiki)
2011	Logbook on documentation of controls, error finds and error eliminations
Uncertainties analysis for the entire source category	
2011	Uncertainties analysis for forest and LULUC calculated
Calculations for Submission 2012	
2011	New calculation of the time series for LULUC (1990-) 2005 through 2009 completed on a test basis
2011	New calculation of the LULUC time series from 1990 to 2010

19.6 Other detailed methodological descriptions for the source category "Waste and wastewater" (6)

19.6.1 Solid waste disposal on land (6.A)

19.6.1.1 Uncertainties for the source category "solid waste disposal on land"

The following uncertainties were estimated by the responsible Federal Environment Agency expert on 23 February 2004. The uncertainties must be considered provisional for the time being, since no national experience has yet been gained with the FOD method. In addition, an effort is being made to hold an experts' hearing that will adjust the estimated uncertainties as necessary, thereby placing them on a broader, more reliable basis.

No.	Definition of time series						Uncertainties data					
	CRF	Source description			Value type (EF / EM / AD)	If EF / EM: Gas	Base year 1990 ⁴		2002		Remarks on considerations, literature sources, etc.	Estimated by
		for example, CSE module name or suitable aggregate within the listed CRF code ¹	If applicable, further source differentia- tion ²	If applicable, CSE time series ID			Uncertainty [+/-%] ³	Distribut ion type ⁵	Uncertainty [+/-%] ³	Distribut ion type ⁵		
1	6A1	Waste landfilling			MSW _T (x)							
2	6A1	Waste landfilling			MSW _F (x)		+/-5%	N	+/-2%	N	for 1990: Low reliability in ABL, no data for NBL	
3	6A1	Waste landfilling			DOC(x)	CH ₄	+/-20%	N	+/-20%	N	Reliable results from projects for study of raw waste in waste- incineration facilities are available	
4	6A1	Waste landfilling			DOC _F	CH ₄	+/-30%	N	+/-30%	N		
5	6A1	Waste landfilling			MCF(x) (for MCF=1)	CH ₄	+ 0% -10%	L	+0% -10%	L	Pursuant to IPCC-GPG	
6	6A1	Waste landfilling			F	CH ₄	+10% -0%	L	+10% -0%	L		
7	6A1	Waste landfilling			k	CH ₄	+50% -35%	L	+50% -35%	L		
8	6A1	Waste landfilling			R(t)	CH ₄	+/-10%	N	+/-10%	N	Pursuant to IPCC-GPG, small by comparison to other uncertainties	
9	6A1	Waste landfilling			OX	CH ₄	+50% -35%	L	+50% -35%	L	Corresponds to a half-life of 3.5 years (k=0.23) to 8 years (k=0.09)	
¹ If the CSE module name and CSE time-series ID are not available for estimation, or are too detailed, the sources may also be defined via CRF, and another unambiguous description, in the field "further source differentiation". ² Pursuant to CSE dimensions, if required for differentiation: e.g. fuel, type of operation, material, equipment, measure ³ With log-normal distribution: [+x%; -y%] ⁴ For F gases, the base year is 1995. ⁵ Distribution types: N (normal distribution); L (log-normal distribution); T (triangular); U (uniform)												

19.6.2 Wastewater (6.B) – Data for determination of emission factors for wastewater and sewage-sludge treatment (6.B.2)

The remarks made in Chapter 14.6.2 of the NIR 2008 apply.

19.6.3 Determination of nitrous oxide emissions from wastewater treatment (6.B.2)

The remarks made in Chapter 14.6.3 of the NIR 2008 apply.

20 ANNEX 4: CO₂ REFERENCE APPROACH; COMPARISON OF THAT APPROACH WITH THE SECTORAL APPROACH; AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE

Information on the CO₂ reference approach, a comparison with the sectoral approach and relevant information on the National Energy Balance are found in Chapter 3.2.1.1.

21 ANNEX 5: ASSESSMENT OF COMPLETENESS, AND ASSESSMENT OF POTENTIALLY EXCLUDED SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS

The following two tables show the sources for greenhouse gases that have not been included in Germany's greenhouse-gas inventories to date. The tables also include explanations of the reasons for such omission. This table is a summary of CRF Table 9(a), which contains a more detailed overview of non-included sources and sinks. Additional information is presented in Chapter 1.8.

Table 314: Completeness - overview of sources and sinks whose emissions are not estimated (NE)

Source category	Greenhouse gas	Explanation
5.A.1 5.A.1 Forest Land remaining Forest Land	CH4	According to IPCC GPG (2003, p.1.11) countries are not required "to prepare estimates for categories contained in appendices,..." .
5.D.2 5.D.2 Land converted to Wetlands	CH4, N2O	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
5.E 5.E Settlements	CO2, CH4, N2O	No data available
5.E.1 Settlements remaining Settlements	CH4, N2O	No data available.
5.E.2 Land converted to Settlements	CH4, N2O	No data available.
5.F 5.F Other Land	CO2, CH4, N2O	No data available
5.F.2 Land converted to Other Land	CH4, N2O	No data available.
5 Forest Land converted to Other Land-Use Categories	CH4	No reliable data is available for reporting on CH4, NOx, CO, NMVOC emissions.
5 Grassland converted to Other Land-Use Categories	CH4	
5.G Harvested Wood Products	CO2, CH4, N2O	According to IPCC GPG 2003 HWP do not have to be reported (p.1.11 chp.1.7).
5.G C from lime to forest	CH4	CH4 emissions from drainage of soils and wetlands do not have to be reported according to GPG IPCC (2003), p. 1.11.
5.A.1 5.A.1 Forest Land remaining Forest Land	N2O	Until now there is no data available on the area of mineral soils drained. Also, according to IPCC GPG (2003, p.1.11) countries are not required "to prepare estimates for categories contained in appendices,..."
5.G C from lime to forest	N2O	N2O emissions from drainage of soils and wetlands do not have to be reported according to GPG IPCC (2003), p. 1.11.

Table 315: Completeness - overview of sources and sinks that are included elsewhere (IE)

Source category	Greenhouse gas	Explanation
1.AA.2.A Iron and Steel	CO2	emissions are reported under 2C1
1.AA.2.B Non-Ferrous Metals	CO2, CH4, N2O	reported under source category 1A2f Other Other because of confidential data
1.AA.2.C Chemicals	CO2, CH4, N2O	reported under source category 1A2f Other (unspecified industrial power plants)
1.AA.2.D Pulp, Paper and Print	CO2, CH4, N2O	reported under source category 1A2f Other (unspecified industrial power plants)
1.AA.2.E Food Processing, Beverages and Tobacco	CO2, CH4, N2O	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
1.AA.3.B Road Transportation	CH4, N2O	CH4 and N2O emissions from lubricants supposed to be included in corresponding emissions from liquid fuels consumed!
1.AA.3.C Railways	CO2	CO2 emissions are included in 1.A.3.E; CO2 emissions from biodiesel are set to zero to be not included in national totals! but thus also not included in total CO2 from biomass!
1.AA.3.C Railways	CH4, N2O	assumption by party: emissions are supposed to be included in emissions from consumption of diesel oil
1.AA.3.D Navigation	CO2	CO2 emissions are included in 1.A.3.E
1.AA.3.D Navigation	CH4, N2O	assumption by party: emissions are supposed to be included in emissions from consumption of diesel oil;emissions from co-incineration of lubricants - tier1 approach
1.B.1.A.2.2 Post-Mining Activities	CH4	considered in 1.B.1.A.2.1
1.B.1.B Solid Fuel Transformation	CO2	considered in 1.A.1.C
1.B.2.B.1 Exploration	CO2, CH4	considered in 1.B.2.a.i
1.B.2.B.5.1 at industrial plants and power stations	CH4	considered in 1.B.2.B.5.2
1.B.2.C.1.1 Oil	CO2, CH4	included in 1.B.2.A.ii
1.B.2.C.1.2 Gas	CO2, CH4	included in 1.B.2.B.iv
1.B.2.C.1.3 Combined	CO2, CH4	included in 1.B.2.A.ii and in 1.B.2.B.iv
1.B.2.C.2.3 Combined	CO2, CH4, N2O	considered in 1.B.2.C.2.1. and 1.B.2.C.2.2.
1.C1.B Marine	CH4, N2O	assumption by party: emissions are supposed to be included in emissions from consumption of diesel oil and heavy fuel oil
2.A.3 Limestone and Dolomite Use	CO2	allocation: 1.A.1.a, 2.A.1 and 2.A.2, 2.A.7, 2.C.1
2.A.7.2a - Ceramic production	CO2	see 2.A.7.2b bricks an tiles
2.C.1.2 Pig Iron	CH4	is considered in CRF 1A2
2.C.1.2 Pig Iron	CO2	is considered in oxygen steel
2.C.1.3 Sinter	CO2, CH4	is considered in CRF 1A2
2.C.1.4 Coke	CO2, CH4	is considered in CRF 1A1c
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs, PFCs, SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.3 Fire Extinguishers	HFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.4 Aerosols/ Metered Dose Inhalers	HFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.7 Semiconductor Manufacture	HFCs, PFCs, SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.8 Electrical Equipment	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.P1 Production	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
3.D.3 N2O from Aerosol Cans	N2O	N2O from Aerosol Cans is reported together with N2o from semiconductor production and production of N-Dodecandiacid at 3D Other - Other Product Use.

Source category	Greenhouse gas	Explanation
5.A.1 Forest Land remaining Forest Land	Carbon	Included in gains.
5.A.1 Forest Land remaining Forest Land	CO2	Due to the stock change method used for the estimation of carbon stock changes in biomass, CO2-emissions are included in category 5.A carbon stock change in biomass
5.A.2 Land converted to Forest Land	CO2, CH4, N2O	included in 5.A.1
5.B.1 Cropland remaining Cropland	Carbon	Included in biomass.
5.B.1 Cropland remaining Cropland	CO2	Included in limestone.
5.B.1 N2O emissions from disturbance	N2O	Included in mineral soils.
5.B.2.1 Forest Land converted to Cropland	Carbon	Included in biomass.
5.B.2.1 Forest Land converted to Cropland	N2O	Included in mineral soils.
5.B.2.2 Grassland converted to Cropland	Carbon	Included in biomass.
5.B.2.2 Grassland converted to Cropland	N2O	Included in mineral soils.
5.B.2.3 Wetlands converted to Cropland	Carbon	Included in biomass.
5.B.2.3 Wetlands converted to Cropland	N2O	Included in mineral soils.
5.B.2.4 Settlements converted to Cropland	Carbon	Included in biomass.
5.B.2.4 Settlements converted to Cropland	N2O	included in mineral soils
5.B.2.5 Other Land converted to Cropland	Carbon	Included in biomass.
5.B.2.5 Other Land converted to Cropland	N2O	Included in mineral soils.
5.C.1 Grassland remaining Grassland	Carbon	Included in biomass.
5.C.1 Grassland remaining Grassland	CO2	Included in cropland.
5.C.1 Grassland remaining Grassland	CO2	Included in limestone.
5.C.2.1 Forest Land converted to Grassland	Carbon	Included in biomass.
5.C.2.2 Cropland converted to Grassland	Carbon	Included in biomass.
5.C.2.3 Wetlands converted to Grassland	Carbon	Included in biomass.
5.C.2.4 Settlements converted to Grassland	Carbon	Included in biomass.
5.C.2.5 Other Land converted to Grassland	Carbon	Included in biomass.
5.D.1 Wetlands remaining Wetlands	Carbon	Included in biomass.
5.D.2.1 Forest Land converted to Wetlands	Carbon	Included in biomass.
5.D.2.2 Cropland converted to Wetlands	Carbon	Included in biomass.
5.D.2.3 Grassland converted to Wetlands	Carbon	Included in biomass.
5.D.2.4 Settlements converted to Wetlands	Carbon	Included in biomass.
5.D.2.5 Other Land converted to Wetlands	Carbon	Included in biomass.
5.E.1 Settlements remaining Settlements	Carbon	Included in biomass.
5.E.2.1 Forest Land converted to Settlements	Carbon	Included in biomass.
5.E.2.2 Cropland converted to Settlements	Carbon	Included in biomass.
5.E.2.3 Grassland converted to Settlements	Carbon	Included in biomass.
5.E.2.4 Wetlands converted to Settlements	Carbon	Included in biomass.
5.E.2.5 Other Land converted to Settlements	Carbon	Included in biomass.
C from lime to forest	CO2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included in limestone use.
Car Tyres	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
Ceramics	CH4	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Ceramics	CO2	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Ceramics	N2O	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Double glaze windows	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under

Source category	Greenhouse gas	Explanation
		total potential emissions.
Glass Wares	CH4	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Glass Wares	CH4	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Glass Wares	CO2	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Glass Wares	CO2	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Glass Wares	N2O	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Glass Wares	N2O	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
lime	CH4	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
lime	CO2	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
lime	N2O	reported under source category 1A2f Other (unspecified industrial power plants) because of confidential data
Magnesium production	SF6	SF6 emissions are reported under 2.C.4 Aluminium and Magnesium Foundries
Military use	CH4	assumption by party: emissions are supposed to be included in emissions from consumption of diesel oil, gasoline, kerosene, and avgas; emissions from co-incineration of lubricants - tier1
Military use	N2O	assumption by party: emissions are supposed to be included in emissions from consumption of diesel oil, gasoline, kerosene, and avgas; emissions from co-incineration of lubricants - tier1
N2O for Medical Using	N2O	The N2O-emissions are reported at 3D Use of N2O.
Other non-specified	CH4	included in 2.C.1.1
Other non-specified	CH4	!! emissions from co-incineration of lubricants in domestic civil aviation!! !! allocated to 1.A.3.e as it is impossible to input data under 1.A.3.a !! CH4: assumption by party: emissions are supposed to already be included in emissions from consumption of kerosene and avgas in civil domestic aviation; !!!emissions from co-incineration of lubricants in domestic civil aviation!!!
Other non-specified	N2O	!! emissions from co-incineration of lubricants in domestic civil aviation!! !! allocated to 1.A.3.e as it is impossible to input data under 1.A.3.a !! N2O: assumption by party: emissions are supposed to already be included in emissions from consumption of kerosene and avgas in civil domestic aviation
Shoes	HFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
Shoes	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
Trace gas	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.

22 ANNEX 6: ADDITIONAL INFORMATION TO BE CONSIDERED AS PART OF THE NIR SUBMISSION (WHERE RELEVANT) OR OTHER USEFUL REFERENCE INFORMATION

22.1 Additional information relative to inventory preparation and to the National System

22.1.1 Definitions in the "National System" principles paper on emissions reporting

In the "National System" principles paper on emissions reporting, state secretaries of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU); Federal Ministry of the Interior (BMI); Federal Ministry of Defence (BMVg); Federal Ministry of Finance (BMF); Federal Ministry of Economics and Technology (BMWt); Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) defined responsibilities pertaining to the various relevant source and sink groups and to the necessary financing for 2008. The agreement reads as follows:

BMU, BMI, BMVg, BMF, BMWt, BMVBS, BMELV Berlin, 5 June 2007

"National System" principles paper on emissions reporting

The state secretaries of the ministries concerned have determined as follows, by common consent, with regard to the issue of the "National System" for emissions reporting pursuant to Art. 5(1) Kyoto Protocol:

- 1. The Federal Environment Agency, Section I 4.6 "Emissions Situation", is the responsible "Single National Entity" (national co-ordinating agency) for reporting pursuant to the UN Framework Convention on Climate Change and the Kyoto Protocol. A country's Single National Entity is responsible for preparing the country's national inventory, working for continual improvement of the inventory, supporting those persons involved in the national system and preparing decisions of the Co-ordinating Committee.*
- 2. A Co-ordinating Committee, representing all affected departments, has been established to deal with all questions arising in the framework of the National System, and to be responsible for official discussion and approval of the inventories and the reports required pursuant to Articles 5, 7 and 8 of the Kyoto Protocol. The Committee shall support all pertinent processes in this framework and, in particular, it shall clarify any pertinent uncertainties – for example, in connection with definition of individual emission factors.*

In particular, the Committee shall define key source and sink categories, and the minimum requirements pertaining to quality control and quality assurance for data collection and processing and to the annual quality control and quality assurance plan.

As necessary, the Committee may specify the methods to be used for calculating emissions in the various source categories and for calculating storage in sink categories. The Committee is chaired by the BMU. The Committee shall meet whenever at least one department sees a need for such a meeting. Subordinate authorities and other institutions involved in inventory preparation may be included in meetings as necessary.

3. *For preparation of the national inventory, such data shall be used, for calculations of emissions and reductions, as are required pursuant to the provisions of Art. 3 (1) of decision 280/2004/EC and of Art. 2 (1) of the Ground rules for calculating emissions in source categories and storage in sink categories. Inventories shall be prepared on an annual basis. In addition, quality assurance in keeping with the requirements of Art. 12 of the rules shall be carried out. Furthermore, reliable documentation and archiving shall be required.*

Existing data-transfer arrangements, such as those made on the basis of voluntary agreements or legal provisions, should not be fundamentally changed; they should only be completed and improved as necessary in order to provide a reliable database. For this reason, the aforementioned responsibilities do not necessarily include data collection and forwarding. With regard to division of responsibilities between BMU/UBA, BMVBS and BMWi, attention is called especially to Annex 1.

The responsibilities for ensuring proper data delivery to the Single National Entity, and for quality control, documentation and data archiving, shall be distributed as follows among the various relevant departments:

a) For source category 1 (Energy) – with the exception of source categories 1.A.3 (Transport) und 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry of Economics and Technology (BMWi) has responsibility.

b) For source categories 2 (Production processes) and 3 (Use of solvents and other products), the Federal Ministry of Economics and Technology (BMWi) has responsibility.

c) For source category 1.A.3 (Transport), the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) has responsibility.

d) For source category 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry of Defence (BMVg) has responsibility. Where data are subject to secrecy provisions, the Federal Environment Agency shall take the relevant secrecy requirements into account.

e) For source and sink categories 4 (Agriculture) and 5 (Land use, land-use changes and forestry), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) has responsibility.

f) For source category 6 (Waste) and source category 7, and well as for issues related to greenhouse-gas emissions from biomass combustion, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has responsibility.

g) The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is also responsible for preparing tables in the standardised reporting format pursuant to Art. 2 (2) letter a of Decision 2005/166/EC (implementation rules) source and sink categories 4 and 5.

In addition, the relevant authorities, as determined by the pertinent statistics regulations, are responsible for tasks relative to official statistics, including data delivery, quality assurance and data documentation and archiving. Co-operation between a) the statistical offices of the Federal Government and the Länder and b) the agencies concerned with reporting is co-ordinated via the Federal Statistical Office. In the process, secrecy requirements pertaining to statistics are to be observed.

4. *The responsible departments shall clarify, in the short term, how proper data provision is to be permanently assured, to the extent such clarification has not already been completed. In particular, this requirement shall apply to agreements, ordinances or laws needed for institutionalisation of the National System. In general, for purposes of emissions reporting, voluntary agreements with associations and/or individual companies shall have the same status as pertinent legal provisions. In addition, as agreed in the co-ordination discussion on 12 September 2006, the Federal Environment Agency and the Federal Statistical Office shall determine what data can be provided, for reporting purposes, from the official statistical system, as well as what additional data should be collected via the official statistical system. The various relevant departments, the Federal Environment Agency and the Federal Statistical Office shall send their pertinent proposals to the BMU by 15 July 2007.*
5. *By 31 July 2007, the BMU shall invite participating departments to co-ordinate pertinent proposals and to establish a schedule for implementing the required instruments. The responsible departments, and the Federal Government, shall arrange for the establishment of the required instruments as quickly as possible.*
6. *Where additional funding is required for execution of the responsibilities mentioned under 3., such funding shall be provided from proceeds from sale of AAUs, via an expansion of the state secretaries' agreement of 22 December 2006 relative to Article 3.4 of the Kyoto Protocol.*

To this end, a budget item for relevant income shall be established within Individual Plan 16 (Einzelplan 16) as of the 2008 fiscal year. Following review by the Federal Ministry of Finance (BMF), the additional requirements requiring financing shall be listed as expenditures within the departments' individual budgets. The departments' additional requirements in this regard must be submitted to the BMF by 6 June 2007.

Should additional budget funding be required in coming years, in addition to the additional requirements determined in connection with the 2008 budget, then suitable relevant amounts of additional AAUs shall be sold in subsequent years.

[...]

Annex: Division of responsibilities between BMU/UBA, BMVBS and BMWi

The BMU, BMVBS and BMWi have agreed that the existing emissions-reporting structures are to be retained and that the Federal Environment Agency (UBA) shall continue to perform its existing tasks with regard to the source categories 1, 1.A.3, 2 and 3. The BMVBS and the BMWi shall ensure that any gaps in the data for those source categories for which they are responsible are closed.

Specifically:

BMWi:

With regard to source category 1: The inventories in this area shall be prepared by the Federal Environment Agency, on a basis that shall include energy data provided by the agency contracted by the BMWi for preparation of energy balances, as well as on the basis of additional relevant statistics and association information.

With regard to source category 2: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG) and from communications of relevant associations / individual companies.

With regard to source category 3: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG), from foreign trade statistics and from communications of relevant associations / individual companies.

Existing requirements for further optimisation shall be clarified, in the short term, by BMWi, BMU and UBA, working in co-ordination. Where data optimisation is required via changes in existing surveys based on the Environmental Statistics Act (UStatG) or on the 13th Ordinance on the Execution of the Federal Immission Control Act (13. BimSchV), the BMU shall be responsible. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

BMVBS:

Emissions relative to source category 1.A.3 (Transport) shall be calculated by the Federal Environment Agency, using the TREMOD model. The BMVBS shall provide data/calculations as needed to close data gaps and determine emissions relative to international air transports or shall ensure that such data/calculations are provided by third parties. At present, emissions from ship transports may be calculated from Energy Balance data, using default emission factors. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

22.1.2 Additional information about the Quality System of Emissions Inventories

22.1.2.1 Minimum requirements pertaining to a system for quality control and assurance

As described above in the main section, the requirements pertaining to the system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung"; last revision: November 2007). These are described below.

22.1.2.1.1 Introduction

Representatives of the departments participating in the co-ordinating committee for the National System of Emissions Inventories define the general minimum requirements, which are described in the present document, for quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions. Such minimum requirements serve as the basis for collection, processing and forwarding of, and reporting on, all data that support the process of reporting on greenhouse-gas emissions.

These minimum QC/QA requirements must be adhered to on all levels of inventory preparation. In many cases, relevant efforts can draw on existing processes and systems, such as the quality standards for public statistics. Annex 1 of the present document describes, by way of example, implementation of the minimum QC/QA requirements and the QC/QA system within the Federal Environment Agency. All participating institutions are

required to submit suitable descriptions of their implementation of these minimum requirements; such descriptions are to be published with the inventory report in the framework of reporting in 2009. On request, the Federal Environment Agency supports participating ministries in preparing QC/QA systems in their relevant areas of responsibility.

22.1.2.1.2 System for quality control and quality assurance

The rules (*Commission Decision 2005/166/EC*) implementing *Decision 280/2004/EC* require national greenhouse-gas inventories to conform to the QC/QA requirements of the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC Good Practice Guidance) and the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC Good Practice Guidance for LULUCF).

The *IPCC Good Practice Guidance* specifies that QC/QA systems must be introduced, with the aim of enhancing transparency, consistency, comparability, completeness and precision of national emissions inventories and, especially, that such inventories must fulfill requirements pertaining to "good inventory practice". A QC/QA system comprises the following:

- An agency responsible for co-ordinating QC/QA activities
- Development and implementation of a QC/QA plan
- General QC procedures
- Source-category-specific QC procedures
- QA procedures and
- Reporting procedures
- Documentation and archiving procedures

QC/QA measures can conflict with requirements for punctuality and cost-effectiveness. Available time, and available staffing and financial resources, should thus be taken into account in any QC/QA-system development. In good practice, more stringent data-quality requirements are applied to key sources. For other source categories, not all source-category-specific QC procedures have to be implemented. In addition, not all measures have to be carried out on an annual basis; for example, data-collection methods have to be reviewed only once in detail. Thereafter, it suffices to carry out periodic controls to determine whether the prerequisites for application of relevant methods are still being fulfilled. Data uncertainty is another factor that enters into requirements pertaining to QC/QA measures. In order to reduce an inventory's overall uncertainty, those source categories that have high levels of uncertainty should be reviewed in detail.

22.1.2.1.3 Agency responsible for co-ordinating QC/QA activities

As the Single National Entity (national co-ordinating agency), the Federal Environment Agency is responsible for the QC/QA system for the national greenhouse-gas inventory. In this function, it has established the position of co-ordinator for the Quality System for Emissions Inventories (QSE). In good practice, each company and organisation involved in inventory preparation appoints a QC/QA co-ordinator and notifies the QSE co-ordinator of such appointment.

A QC/QA co-ordinator has responsibility for ensuring that a relevant QC/QA system is developed and implemented. Such implementation should be suitably institutionalised – for example, by means of an in-house directive or association agreement.

In order to ensure that the Single National Entity can efficiently carry out its supporting tasks, the persons responsible for the following additional functions should be announced (by name) to the QSE co-ordinator:

Responsible expert (Fachverantwortlicher) – Person responsible for data collection, data entry and pertinent calculation, in keeping with the prescribed methods, as well as for carrying out QC measures and preparing a relevant textual contribution for the National Inventory Report.

Quality control manager (Qualitätskontrollverantwortlicher) – Person responsible for checking and approving data and report sections (the QC/QA co-ordinator may also perform this function).

22.1.2.1.4 QC/QA plan

The purpose of the QC/QA plan is to ensure that QC/QA measures are properly organised and executed. It includes a description of all required QC/QA measures and a schedule for implementation of such measures. The QC/QA plan also defines the primary emphases of such measures. The criteria for selection of source categories for detailed review include the following:

- The source category's relevance (key source yes/no, uncertainties high/low)
- The time of the last detailed QC/QA measure for the source category, and the results of such measure
- Changes in methods or the pertinent database
- Results of annual inventory review in keeping with the UN Framework Convention on Climate Change and the Kyoto Protocol
- Available resources for execution of QC/QA measures

Good practice calls for establishing a QC/QA plan and then reviewing and updating it each year after the latest inventory has been prepared.

On the basis of the results of annual inventory review, and of the results of QC/QA measures of which it is aware, the Single National Entity prepares an improvement plan for the entire inventory. On this basis, in turn, it derives proposals for a binding inventory plan for the next report year. Such proposals are then submitted to the co-ordinating committee for approval. The QC/QA co-ordinator, working in co-operation with the QSE co-ordinator in the Single National Entity, defines the procedures, scheduling and scope for inclusion of his institution's QC/QA measures in the inventory plan for the overall inventory.

22.1.2.1.5 General quality control

Pursuant to the definition used by the IPCC (Chapter 8.1 *Good Practice Guidance*), quality control (QC) comprises a system of routine specialised measures for measuring and checking the quality of inventories in preparation.

Consequently, a QC system should achieve the following:

- Facilitate routine, standardised checks in the interest of data integrity, correctness and completeness;
- Identify and eliminate errors and omissions;
- List and archive inventory material and record all QC activities.

Table 8.1 of the *IPCC Good Practice Guidance* includes a complete list of general QC measures. Requirements pertaining to general, Tier-1 QC procedures can be derived from the requirements mentioned in Chapter 8.6 of the *IPCC Good Practice Guidance*. Typical general quality control measures in activity-rate determination include checking data for transfer errors, checking data for completeness, checking formulae for combining data and carrying out plausibility checks with the help of external data sources and earlier calculations. Suppliers of emissions calculations have to carry out additional QC measures – for example, checking formulae for emissions calculation.

Required quality controls should be recorded in checklists. Such lists should include at least the checking measures carried out, the results of checking, any pertinent corrections made and the name of the person(s) responsible for the measures. Annex 2 of the present document includes a sample checklist of the Federal Environment Agency.

Not all quality controls have to be carried out on an annual basis; some may be implemented at longer regular intervals. This applies especially to aspects of data collection that do not change from year to year. Requirements pertaining to the frequency and completeness of QC measures are more stringent for key sources than for other source categories. It should be ensured that all source categories undergo detailed quality control at least periodically.

22.1.2.1.6 Source-category-specific quality control

Available resources permitting, particularly relevant source categories (such as key sources), in addition to undergoing Tier 1 procedures, should undergo Tier 2 quality control with regard to determination of activity data, emissions and uncertainties (cf. Chapter 8.7 *Good Practice Guidance*). The chapters of the *IPCC Good Practice Guidance* that pertain to the various individual source categories (Chapters 1-5) include additional information relative to source-category-specific QC measures. Such guidelines must be observed in preparation of any QC/QA plan:

Where combined **activity data** from secondary sources are used, good practice calls for evaluating pertinent QC measures in connection with preparation of such secondary sources. If the level of such measures is adequate, it suffices to call attention to this fact in the documentation. Where secondary sources do not fulfill minimum requirements pertaining to quality control, suitable QC/QA checks should be carried out by the institution that uses the data. Results of subsequent QC/QA checks should enter into determination of uncertainties for activity data. In addition, wherever possible, a range of different sources should be compared for purposes of determining data quality.

In use of facility-specific activity data, it is good practice to review the methods and QC/QA standards applied to data collection. Where such methods and standards do not meet minimum requirements, the advisability of using the data should be reconsidered and the uncertainties should be adjusted as necessary.

With regard to **emissions data**, it is good practice to review the emission factors that have been used. Such efforts include using national emission factors for key sources and reviewing the validity of IPCC standard factors under the applicable national circumstances. Where emissions data are obtained via direct measurements, it is good practice to review the relevant measurement methods and the quality standards applied. Emissions data and emission factors should be reviewed in light of data from previous years, and from independent sources, and any resulting discrepancies should be explained.

Quality control for uncertainties includes checking to determine whether calculations are free of errors and whether documentation for reproduction of results is adequate. In use of experts' assessments, the pertinent experts' qualifications and estimation methods should be reviewed and documented.

22.1.2.1.7 Quality assurance procedures

While the primary aim of quality control is to ensure that methods are correctly applied, the primary purpose of quality assurance is to examine methods as such and improve them as necessary.

Pursuant to the relevant IPCC definition (Chapter 8.1 *Good Practice Guidance*), measures for **quality assurance** (QA) are based "*on a planned system of reviews by persons who are not directly involved in preparing the inventory. Such reviews – which are best carried out by independent third parties – should be applied to completed inventories, after QC procedures have been carried out. Such measures accomplish the following:*

- Verify that data-quality criteria are fulfilled,
- Ensure that the inventory takes account of the best available estimates of emissions and sinks, in keeping with the latest scientific findings and available data, and
- Promote the efficiency of the QC system".

The required instrument for quality assurance is the peer review. While use of audits is encouraged, audits are not required.

22.1.2.1.8 Reporting procedures

The Single National Entity is responsible for initiating and co-ordinating reporting and carrying out relevant overall organisation. Provision of data and reports by third parties must conform to applicable requirements pertaining to the scope, form and scheduling of/for such provision.

22.1.2.1.9 Documentation and archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations after the fact. The general requirements pertaining to documentation and archiving for the entire process of preparation of greenhouse-gas inventories are described in Chapter 8.10.1 of the *IPCC Good Practice Guidance*.

Consequently, data providers have the obligation to keep records of the following information relative to data they supply to the Federal Environment Agency, for purposes of inventory calculations:

Data providers:

- Publication / source of activity data, with detailed referencing of the relevant Table numbers and names, and of the relevant pages in the original sources;
- Survey contents (definitions of the surveyed characteristics, delimitations used, survey units used) and survey methods;
- The legal foundations and ordinances on which surveys are based;

- Chronological and spatial comparability with previous-year data, and any changes with regard to definitions, scopes of validity, cut-off points, sources of activity data or data-collection methods;
- Any revision of previously published data;
- The accuracy or quantitative error of activity data, methods used to estimate errors and the names of experts who have carried out error estimation.
- Secrecy and data protection: suitable notification with regard to any individual data items that are considered secret.

Such materials should be provided to the Federal Environment Agency on an annual basis, together with pertinent data, and they are centrally archived by the Federal Environment Agency.

Quality control (QC)

The records kept in the framework of quality control should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality control carried out, the dates on which quality control measures were carried out, the pertinent results, and the corrections and modifications triggered by quality control measures. In each case, record-keeping and archiving for quality control measures are carried out internally, by the institution supplying the pertinent data. A general description of regularly executed quality control measures is provided to the Federal Environment Agency for purposes of the national inventory report and inventory review.

Providers of emissions calculations

For providers of emissions calculations, the minimum requirements pertaining to record-keeping also include the following:

- Description of the pertinent calculation methods and reasons why the methods were selected;
- Assumptions and criteria pertaining to selection of activity data and emission factors;
- Documentation pertaining to emission factors and their sources, with detailed references to the relevant numbers and pages in original sources;
- Calculation models;
- Calculation files, calculation software.

Points 1-4 are recorded and archived along with descriptions provided for the national inventory report. Separate documentation pertaining to calculation models must be provided, in keeping with general scientific practice, and along with internal documentation in the form of manuals or guides. Data suppliers archive calculation files and calculation software, and keep pertinent records, on an internal basis. Such materials should be provided to the Federal Environment Agency as necessary in the framework of inventory review.

Quality assurance

In addition to carrying out quality control measures, providers of emissions calculations are obligated to carry out quality assurance. The records kept in the framework of quality assurance should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality assurance carried out, the dates on which quality assurance measures were carried out, the pertinent results, and the corrections and

modifications triggered by quality assurance measures. In addition, records should be kept of source-category-specific quality controls.

In each case, record-keeping and archiving relative to pertinent quality assurance are carried out internally, by the relevant data-supplying institution. In addition, pertinent quality assurance measures are summarised in the national inventory report.

Confidential data / secrecy

In general, confidential data must be designated as such when they are provided, to ensure that the proper precautions are taken when they are used.

In inventory review, general obligations apply whereby confidential data must be disclosed in cases in which inventory reviewers consider such disclosure to be necessary to ensure that emissions calculations are transparent and clear. The extent to which such disclosure actually must involve disclosure of individual data items should be clarified on a case-by-case basis with the institution providing the data.

22.1.2.1.10 Annex 1: Minimum requirements pertaining to quality control and quality assurance in emissions reporting in the Federal Environment Agency

22.1.2.1.10.1 Introduction

The general minimum requirements, as approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions apply to all participants. These requirements are the basis for collecting, processing, forwarding and reporting of/on all data that support reporting on greenhouse-gas emissions. They are thus binding for all working groups involved, in the Federal Environment Agency, in fulfillment of this reporting task.

22.1.2.1.10.2 System for quality control and quality assurance

In addition to the general minimum requirements, approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions, the specific provisions of in-house directive (Hausanordnung) No. 11/2005 also apply at the Federal Environment Agency. Pursuant to that directive, the pertinent procedure defined in the QSE manual is binding for all Federal Environment Agency personnel involved in emissions reporting (Rules of procedure of the Federal Environment Agency (Geschäftsordnung des Umweltbundesamtes), Volume II, Numeral XV).

The in-house directive fully implements the requirements of Chapter 8 of the IPCC *Good Practice Guidance*. Suitable UBA-specific instruments have been established to ensure effective identification and execution of measures for continual inventory improvement (improvement plan and inventory plan; cf. 22.1.2.1.10.3). That work has led to the development of the Quality System for Emissions Inventories (QSE), via which the points mentioned in Chapter 22.1.2.1 have been implemented.

22.1.2.1.10.2.1 Agency responsible for co-ordinating QC/QA activities in the Federal Environment Agency

Pursuant to in-house directive No. 11/2005, section FG I 2.6, "Emissions Situation", is the "Single National Entity" (SNE) within the Federal Environment Agency. In the Federal

Environment Agency's organisational diagramme, the so-defined SNE is thus included in the Federal Environment Agency's group of "focal points" and liaison offices for international organisations. In addition, this assignment of responsibility was confirmed by the relevant ministries via a state secretaries' resolution of 5 June 2007.

The roles and responsibilities of the Single National Entity, and of the specialised departments participating in emissions reporting, are described in Chapter 3.2, "Roles and responsibilities", of the QSE manual. The Single National Entity is responsible for updating and managing the QSE manual and its appendices and annexes. In carrying out this responsibility, the SNE is assisted by the contact persons named to it by the relevant specialised departments. The version of the QSE manual and its co-applicable documents published on the Single National Entity's intranet is the binding version of these materials.

22.1.2.1.10.2.2 Reporting procedures

In many cases, complex activities comprise numerous different, but related and cumulative, activities (processes) that lead to the production of a single product. To manage such processes effectively, one must strive to understand the manner in which the processes function (or should function), to describe such functioning in logical, realistic ways (activities, dependencies, responsibilities, and many more) and to interrelate the processes in a useful way.

In practice, workflows of complex processes cannot always be fit smoothly into the hierarchical, traditional structures of companies and institutions. The required processes are often diametrically opposed to such structures, since they have to cut across different organisational units. To organise interrelated work processes in a manner oriented to production of the desired product, one must look outside of rigid hierarchies and redefine the processes with a view to improvement.

For this reason, emissions reporting was first described as a process that, via a number of interrelated activities, leads to a product (NIR and inventories) (cf. Figure 68). Additional relevant information is provided in the QSE manual, Chapter 4.3.

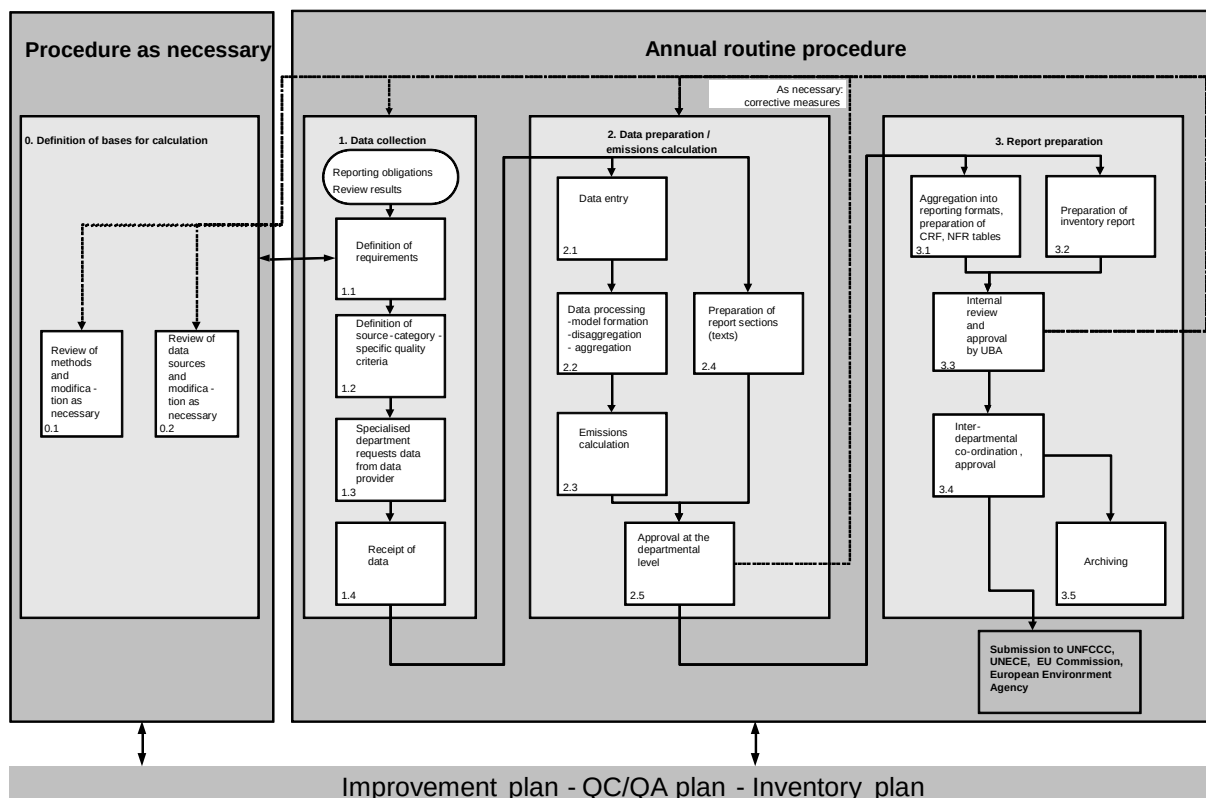


Figure 68: Overview of the overall emissions-reporting process

Via a role concept, suitable responsibilities have been assigned to cover the activities within the main processes and sub-processes shown. Each responsibility thus involves execution of pertinent processes. To understand this approach, it is useful to consider the situation in which many different people carry out the same basic activities even though they work in different work units and source categories. In the present case, this situation was approached by defining a certain group of persons (persons with a specific role – for example, responsible experts). That group was then seen to be subordinate to another group of persons (with a different role – for example, specialised contact persons) that ensures that the first group observes and fulfills the requirements pertaining to its work. In addition, a QSE co-ordinator was appointed, in keeping with relevant requirements of the IPCC (cf. Chapter 22.1.2.1.2), to ensure that the system is refined and improved as necessary.

Overall, a comprehensive role concept was developed that addresses the many different requirements applying to the Federal Environment Agency in its task as Single National Entity. The roles involved include the following:

1. Responsible expert at the operational level (FV)

- Main responsibilities: data collection, data entry, calculations with prescribed methods, execution of QC measures, preparation of the NIR text.

2. Quality control manager (QKV)

- Is the superior for the FV
- Main responsibilities: checking and approving data and report sections

3. Specialised contact person (FAP)

- Member of the Single National Entity's staff

- Main responsibilities: providing source-category-specific support for involved experts (inventory work and report preparation) and quality control / quality assurance relative to pertinent source categories in the NIR and CSE.

4. Co-ordinator for the national inventory report (NIRK)

- Member of the Single National Entity's staff
- Main responsibilities: co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR

5. CSE co-ordinator (ZSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance of databases, emissions calculation and aggregation, overarching QC and QA in connection with data entries and calculations for the inventory

6. QSE co-ordinator (QSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance and refinement of the QSE (system, checklists, improvement plan, inventory plan, QC/QA plan and QSE manual)

7. NaSE co-ordinator (NaSEK)

- Member of the Single National Entity's staff
- Main responsibilities: schedule-conformal, requirements-conformal reporting, providing for involvement of national institutions, establishing/recording legal agreements

As a rule, each of the above-described roles will have tasks in several different main and sub-processes of emissions reporting.

22.1.2.1.10.3 QC plan, QA plan and inventory plan

To ensure that all potential improvements identified during the course of inventory work are systematically implemented, identified improvements must be listed in a co-ordinated way. In the process, identified potential improvements should be listed together with all relevant information (origin of the potential improvement, source category, pertinent responsibility, priority, etc.) needed for efficient further processing. Planning and arrangements for implementing identified potential improvements (required actions / corrective measures, deadlines, etc.) should then be made on the basis of such information.

In the interest of proper control and record-keeping in the framework of the NaSE and the QSE (cf. Figure 69), procedures have been defined for processing identified potential improvements for their systematic management and further use. The overall aim is to answer the central question of WHO should do WHAT, HOW, WHEN and WHY:

WHO: This provides the reference to the role concept: A certain person xy is responsible – for example, in the role of responsible expert (FV)

WHAT: This provides the reference to the object that is to be improved – for example, the CO₂ calculation in source category xy needs to be improved

- HOW:** This provides the reference to the aim that is to be achieved – for example, a certain improvement, pursuant to an inventory plan or checklist.
- WHEN:** This provides the reference to the time by which the improvement must be completed, pursuant to the inventory plan
- WHY:** This provides the reference to the origin of the necessary action – for example, the improvement must be carried out as a result of a recommendation via the UNFCCC review process

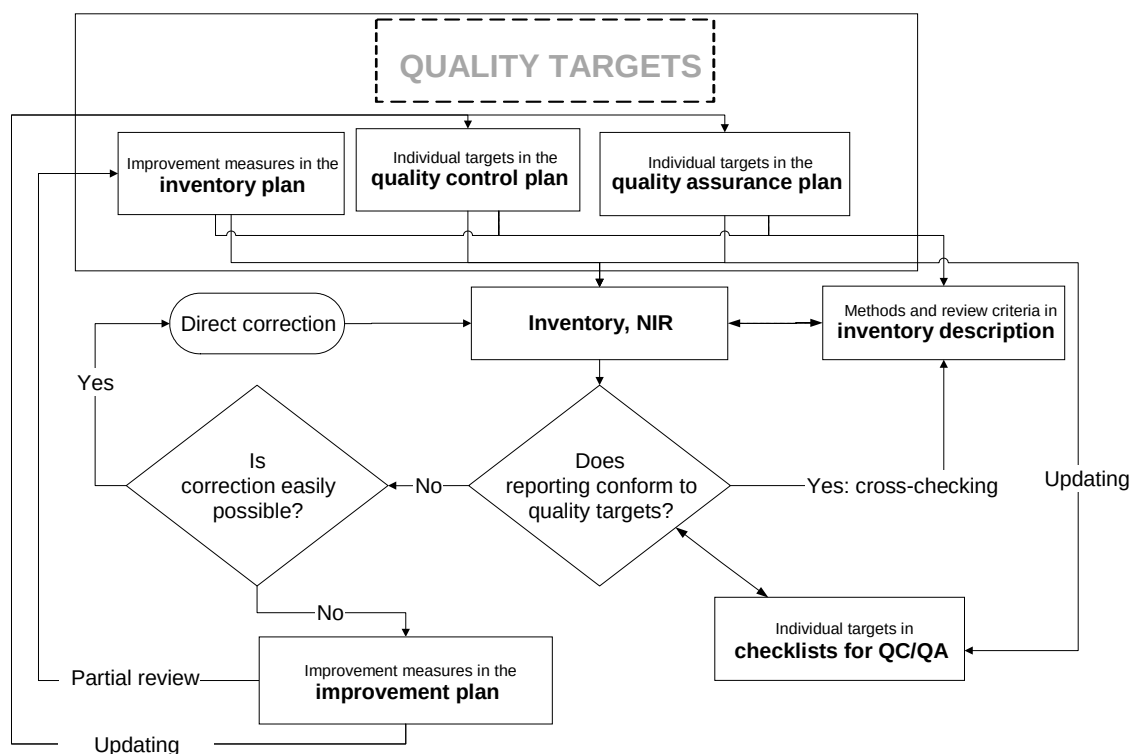


Figure 69: Control and documentation in the framework of the NaSE and the QSE

The **quality targets** have been derived from the general quality aims of the *IPCC Good Practice Guidance* (transparency, consistency, accuracy, comparability, completeness). In addition, operational individual objectives, relative to quality control and quality assurance, for the various source categories, have to be derived from comparison of the requirements from the *IPCC Good Practice Guidance*, the results of independent inventory review (UNFCCC and EU) and assessment of inventory realities.

In an **improvement plan**, all potential improvements and criticisms resulting from independent inventory review are collected and assigned potential corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, via consultations with the relevant responsible experts, integrates them as necessary within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process in the Federal Environment Agency and in the co-ordinating committee. It is thus a binding set of specifications for improvements to be carried out in future.

In the interest of transparent, effective control and execution of inventory-improvement measures, such measures, in keeping with the *IPCC Good Practice Guidance* (Chapter 8.5) are defined role-specifically, as well as source-category-specifically as necessary, in the **quality control plan / quality assurance plan (QC/QA plan)**. The QC plan is oriented

solely to quality control aims for the inventory. In the QA plan, quality assurance objectives may be focused on the inventory, the reporting process or the QSE itself. Furthermore, the quality assurance plan includes scheduling of quality assurance measures to be performed by external third parties.

The **checklists for quality control and quality assurance** list all individual objectives in the emissions-reporting process, in keeping with the pertinent quality control and quality assurance plans. The checklists, which are designed to facilitate review of achievement of individual objectives, are made available to all persons responsible for quality control and quality assurance. The checklists are used to record execution of measures for quality control and quality assurance. Where individual objectives are not achieved and direct correction is not possible, a pertinent entry must be made in the improvement plan (see above).

22.1.2.1.10.4 Procedures for general and source-category-specific quality control

From the requirements set forth in the IPCC Good Practice Guidance, the Federal Environment Agency has developed a checklist concept via which quality requirements are formulated as specific targets. Every effort should be made to achieve such targets. When a target is achieved, such achievement is noted and described in the checklists. The possible entries for such records include "yes" (the target was achieved), "not relevant" (the target as formulated does not correspond to the special situation for the source category in question; this answer is seldom a viable option) and "no" (it was not possible to achieve the target).

Each checklist includes a general section that reflects all Tier 1 QC requirements from IPCC Good Practice Guidance and that is used in connection with every instance of reporting. In addition, each checklist contains a source-category-specific section (Tier 2) that provides concrete objectives for the relevant key source area.

Checklists are provided only for the first five roles within the role concept. Where different roles are responsible for different main and sub- processes of emissions reporting (cf. Chapter 22.1.2.1.10.2.2), checklists will also be oriented to several different main and sub-processes of emissions reporting. They thus represent a cross-section of emissions reporting. The checklists of the FV and the FAP include a basic common set of goals. The FAP are responsible for checking the work of the FV, and such checking is most effective when both roles are oriented to the same goals.

22.1.2.1.10.5 Quality assurance procedures

In the role concept, procedures are designed to ensure that quality assurance is always supported by a "four-eyes" principle. The specialised contact persons (FAP) have the task of ensuring that the emissions calculations and textual work of the responsible experts (FV) are of the proper quality.

In its section on "Expert Peer Review", the IPCC notes that the (above-described) formal procedure selected by the Federal Environment Agency can complement, but not replace, expert peer review (Good Practice Guidance; Chapter 8.8). In one solution found for addressing the justified call for inclusion of external experts, within the framework of available resources, detailed review of specific issues is carried out by external third parties via research projects and studies. In general, the two sides involved (i.e. FV and FAP) jointly manage the process of commissioning third parties. In another means found for addressing

the need for third-party inclusion, workshops on the National System are held at irregular intervals. For such workshops, national experts are invited to come to the Federal Environment Agency for discussion with Federal Environment Agency experts (FV) on current inventory issues relative to selected source categories.

No audits have been carried out in the Federal Environment Agency to date, and none are planned at present. According to the Good Practice Guidance, audits are not absolutely required.

22.1.2.1.10.6 Documentation and archiving

Standardised record-keeping and archiving procedures are to be used in preparation of German greenhouse-gas inventories. At the same time, it is important to differentiate between the central record-keeping and archiving carried out by the Single National Entity and the non-central record-keeping and archiving carried out by the specialised departments of the Federal Environment Agency and of other institutions.

Record-keeping procedures for data and context information vary in accordance with specific requirements. In their information storage, they overlap to some degree, with such overlapping consisting partly of redundancies and partly of storage of similar items at differing levels of detail. On a regular basis, consistency must be ensured for both types of overlapping.

To ensure that all of the Federal Environment Agency's working units use basically consistent procedures, the specifications applying to the instruments used in such procedures – including both general specifications and specifications developed especially for emissions reporting – must be complied with. For purposes of "documentation" (i.e. record-keeping), the Federal Environment Agency has access to the instruments described in Table 316. The specifications pertaining to each type of document / record must be observed. Where no special specifications apply, the provisions from the "General minimum requirements for quality control and quality assurance in reporting on greenhouse-gas emissions" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung") apply.

Table 316: Documentation / record-keeping instruments at the Federal Environment Agency

Instrument	Specifications
Publicly available	
National inventory (CRF tables, CRF-Reporter)	Annex 2, QSE manual: instructions for carrying out recalculations in the CRF tables
National inventory report	Annex 3, QSE manual: specifications for preparing report sections in the context of the National System
Publication	Rules of procedure of the Federal Environment Agency: Point 6.2 Publications
Published manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications
Centralised, and internally available, at the Single National Entity	
CSE database	Annex 5, QSE manual: specifications for data recording within the CSE
Inventory description	Annex 4, QSE manual: requirements pertaining to documentation (record-keeping) and archiving
De-centralised, and internally available	
Files of the central registry	Rules of procedure of the Federal Environment Agency: Point 4.2.10 Handling of files
Reference files	no special specifications
Internal manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications

An integrated documentation / record-keeping concept defines what key content should be stored in the aforementioned documentation instruments. It also defines how a suitable referencing system is to be used to ensure consistency and transparency throughout all such instruments (cf. Annex 4, QSE manual).

22.1.2.1.11 Annex 2: Example of a general checklist for the responsible-expert role

The example presented below (last revision: CHKL 2010) includes only the relevant requirements. Detailed information has been removed in the interest of clarity.

Table 317: General checklist for responsible experts

Process No.	Sub-process name	Individual goal	Optional goal
Main process: 0. Definition of bases for calculation			
0.1	Review of methods, and modification as necessary	The calculation method is in conformance with current key-source analysis.	
0.1	Review of methods, and modification as necessary	The calculation method has been selected in accordance with, or accords with, the pertinent decision tree of the IPCC Good Practice Guidance.	Departures from the decision tree of the IPCC Good Practice Guidance have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.
0.1	Review of methods, and modification as necessary	The calculation method has been selected in keeping with requirements from the inventory plan.	Departures from the inventory plan have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.
0.1	Review of methods, and modification as necessary	The selected calculation method can be applied to the entire time series as of 1990, or is already being consistently applied.	In cases of changes of methods in the time series, recalculation pursuant to the QSE manual (Annex 2), and proper pertinent documentation, are assured.

0.1	Review of methods, and modification as necessary	Departures from the objectives required via 0.1.01-0.1.04 have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.	
0.2	Review of data sources, and modification as necessary	Have new data sources been used?	
0.2	Review of data sources, and modification as necessary	The data source(s) is / are / will be available throughout the long term (for example, on the basis of legal provisions, long-term agreements [> 3 years], etc.).	
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Gaps in the data available for time series as of 1990 have been properly and logically explained, and have been duly documented.
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	A suitable procedure (interpolation/ extrapolation) has been chosen for dealing with data gaps, in conformance with IPCC Good Practice Guidance (Chap. 7.3.2.2), and the procedure has been logically documented. Note: Continued use of the same value is not extrapolation !
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Following closure of data gaps, time-series recalculation has been carried out as necessary, pursuant to QSE manual (Annex 2), and such recalculation has been documented and substantiated in the NIR and CRF.

Process No.	Sub-process name	Individual goal	Optional goal

0.2	Review of data sources, and modification as necessary	The data source(s) completely cover the source category.	The incomplete coverage has been addressed in an extrapolation and has been taken into account in the uncertainties calculation. All steps have been documented and justified clearly and logically.
0.2	Review of data sources, and modification as necessary	Uncertainties information (amount and distribution) is available for the data source(s).	
0.2	Review of data sources, and modification as necessary	The EF and the AD agree in terms of the manner in which they are tailored to the source category.	In the case of discrepancies between the EF and AD, other data sources can establish agreement between the two values. Alternatively, the lack of agreement has been taken into account in an extrapolation, and in the uncertainties calculation, and the entire process has been properly and logically documented.
0.2	Review of data sources, and modification as necessary	The procedures for calculating outset data are clearly described.	
0.2	Review of data sources, and modification as necessary	The data source(s) have been selected in keeping with requirements from the inventory plan.	Any discrepancies have been clearly and logically justified and documented.
0.2	Review of data sources, and modification as necessary	The assumptions and criteria upon which the relevant data source(s) have been selected have been clearly and logically documented.	
0.2	Review of data sources, and modification as necessary	The data provider has carried out routine quality controls of the data source(s). For one-time projects, one-time quality controls have been carried out. Execution of the controls has been duly documented.	

0.2	Review of data sources, and modification as necessary	In use of one/more new data sources, a recalculation pursuant to the QSE manual (Annex 2) was carried out on the basis of this/these other data source(s).	
0.2	Review of data sources, and modification as necessary	In use of IPCC default EF, the manner in which the EF were generated has been reviewed in light of national circumstances, and the EF may be used for Germany. The result of such review has been duly documented.	For IPCC default values that do not fit with national circumstances, the discrepancies have been taken into account in the uncertainties and documented.
0.2	Review of data sources, and modification as necessary	In use of EF other than the IPCC default EF, use of such EF has been clearly and logically justified and substantiated. Note: Use of other EF is permissible only when such EF permit more precise calculation of country-specific emissions.	
0.2	Review of data sources, and modification as necessary	The AD used have been compared with other data sources (for example, EU-ETS, IEA, EPER, etc.), and the result has been duly documented.	

Main process: 1. Data collection

1.1	Definition of requirements	The requirements pertaining to data reflect the information and indications from the inventory plan and the inventory reviews (for example, S&A Report, Centralized Review).	

Process No.	Sub-process name	Individual goal	Optional goal

1.3	The relevant specialised department requests the data from the pertinent data provider(s)	The requirements pertaining to QC and data formats have been forwarded to the data suppliers and/or contracting entities, and such forwarding has been duly documented. Note: Where data suppliers are involved via NaSE agreements, this objective has been achieved.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The data provider or contracting entity has carried out the required quality controls and made proper records of such action.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The received data are complete, without any gaps.	All data gaps in the time series as of 1990 have been closed, in accordance with the IPCC Good Practice Guidance, via extrapolation/interpolation (Chapter 7.3.2.2) and duly documented and justified. Note: Continued use of the same value is not extrapolation
1.4	Receipt of data	The data received are consistent with the previous year's data, and they have been properly described.	Any marked discrepancies with the previous year's data have been duly documented and justified.
1.4	Receipt of data	The order of magnitude of the received data is in line with that of comparable data from other sources (such as ETS data, IEA, EPER, etc.). The result of the review has been duly documented.	The reasons for any discrepancies have been clearly and logically explained and duly documented.
1.4	Receipt of data	The methods/assumptions on which the uncertainties determinations are based have been clearly and logically documented.	Where it was not possible to derive assumptions, expert assessment was carried out, and the relevant expert's quantification was clearly and logically documented.

1.4	Receipt of data	The uncertainties determinations are complete and plausible.	

Main process: 2. Data preparation / emissions calculation

2.1	Data entry (preferably into the CSE)	All of the EF have been entered into the CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the EF data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.1	Data entry (preferably into the CSE)	Development of the EF within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible EF have been corrected.
2.1	Data entry (preferably into the CSE)	All of the AD have been entered into the CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the AD data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	

Process No.	Sub-process name	Individual goal	Optional goal
2.1	Data entry (preferably into the CSE)	Development of the AD within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible discrepancies have been corrected.
2.1	Data entry (preferably into the CSE)	Following entry of all data into the CSE, all entered figures, units and conversion factors have been checked for correctness and confirmed.	
2.1	Data entry (preferably into the CSE)	All of the uncertainties have been entered into the CSE and have been documented in keeping with the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.2	Data preparation (model formation, disaggregation, aggregation)	The inventory description includes an adequate description of pertinent models, with regard to organisation, structure, calculation procedures, assumptions, etc..	
2.3	Emissions calculation	The current inventory calculations have been checked against calculations from previous reports.	Where any significant changes or obvious deviations from an expected trend have occurred, the pertinent calculation, and the data used in calculation, have been reviewed, and any persisting discrepancies have been properly, clearly and logically explained and duly documented.
2.3	Emissions calculation	The results of emissions calculation for current / previous reports have been checked against other data sources for Germany, especially ETS data, and found to be comparable. The result has been duly documented.	Where comparability has not been found, or no comparison was carried out, the pertinent reasons have been properly, clearly and logically explained.
2.3	Emissions calculation	The national Implied EF (cf. S&A Report I) from the previous report is comparable with the Implied EF of other countries (same order of magnitude).	Extreme Implied EF have been properly, clearly and logically explained, and duly documented, in the NIR, or reference to an existing explanation has been made.

2.4	Preparation of report sections (texts)	The source category has been completely and logically described, for the NIR, in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	
2.5	Approval by the relevant experts	The values of AD, EF and ED, of their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	
2.5	Approval by the relevant experts	Documentation of the origins for AD, EF and ED data, and for their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	Lacking or incomplete documentation of data origin has been properly, clearly and logically explained and duly documented.

22.1.3 The database system for emissions – Central System of Emissions

Since 1998, the Federal Environment Agency has maintained and managed an IT tool for inventory preparation: the *Central System of Emissions (CSE)*, an integrated national database. The CSE implements the diverse requirements pertaining to emissions calculation and reporting, and it automates key steps in such work. It supports the processes of inventory planning and reporting (for example, by carrying out emissions calculations and recalculations, and relevant error analysis); inventory management (for example, by carrying out archiving and annual data evaluation); and quality management at the data level (cf. UBA 2003a, Projekthandbuch Decor (Decor project handbook)). The CSE makes it possible to fulfill the key requirements of transparency, consistency, completeness, comparability and accuracy at the data level.

Data documentation plays a central role in the CSE. The CSE stores such information as who is responsible for handling specific tasks; data sources and calculation procedures; uncertainties in time-series values; and records of changes, including the relevant times and persons responsible. With its history-management functionality, the system archives deleted values and can restore them as necessary. Such functionality thus makes it possible to trace and reconstruct data as necessary, and it provides a basis for independent, third-party reviews. The system also provides mechanisms that support quality assurance at the data level (e.g. components for detecting uncertainties and checking plausibility). Above all, transparency is accommodated by ensuring that data are recorded within the same structure in which they are provided, and that all processing and transformations into a reporting format take place first in the CSE itself, and thus remain open to examination. In addition, the CSE manages detailed technology-specific activity data and emission factors that can be processed, via calculation rules (calculation methods), into aggregated, source-category-specific values for the various reporting formats. Aggregation of individual CSE time series for the CRF report lines, for example, is described in Annex 3 and Chapter 3ff – in each case, with regard to individual source categories. In addition to aggregation and model formation for calculations, the CSE also supports scenario and forecast calculations.

Data exchange within the framework of the National System – i.e. within the Federal Environment Agency and with third parties – is also organised via the Central System of Emissions. Such processes involve both direct data entry and imports of aggregated values, from existing databases and via a standard interface (for example, transport data from the TREMOD database and agricultural data from the GAS-EM database). Ideally, inventory data should be entered into the CSE directly by the relevant responsible experts or should be

imported, by the CSE administrator, via the import interface. This applies to in-house UBA employees as well as to external parties involved in the National System. To this end, a range of measures have been implemented:

- Provision of a *standardised import format for CSE* in 2002 has facilitated the direct import of data from other emissions-relevant databases.
- In September 2002, participating technical experts from the Federal Environment Agency were given direct access to the CSE via the Federal Environment Agency intranet. The relevant parties are identified via an annual survey of specialisations; as a result, virtually all of the responsible experts at the Federal Environment Agency now have such access. However, write-access rights for these experts are normally confined to the database content for which they are technically responsible.
- Since November 2002, training courses on CSE procedures have been held on an annual basis for involved Federal Environment Agency staff.
- Since 2005, qualitative and quantitative information about data uncertainties has also been included in the CSE.
- Since 2006, reporting obligations under the Geneva Convention on Long-Range Transboundary Air Pollution and EU legislation (such as the NEC directive) have been fulfilled via the CSE.
- Since 2008, data providers and experts outside of the Federal Environment Agency, and project partners, can work interactively with the CSE via remote access.

Launch of the fully operational version of the CSE, in 2002, fulfilled the principal technical requirements for compliance with the Kyoto requirements for inventories; the next stage now is to make all emissions-calculation and data-collection procedures completely interoperable with the CSE. Numerous efforts in this regard have already been undertaken in the past, including integration of Reference Approach calculations and implementation of extensive data-secrecy requirements. Planned future efforts in this regard include improving the CSE's forecasting and scenario-calculation functionalities. All in all, the system – including both its technological functionalities and its database – is continually being adjusted and improved.

22.2 Supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

22.2.1 KP-LULUCF

The CRF tables are reported separately.

22.2.2 Standard Electronic Format (SEF) Tables

22.2.2.1 Standard Electronic Format for the reported year 2008

UNFCCC SEF application

Version 1.2

Workflow Unlock file Completeness Check Consistency Check Lock file	Settings Party: Germany ISO: DE Submission year: 2010 Reported year: 2009 Commitment period: 1 Completeness check: YES Consistency check: YES File locked: YES Lock timestamp: 06.01.2010 09:19 Submission version number: 2 Submission type: Official
Functions Mandatory data Import XML Reset SEF Export XML Export XML (Imported)	

Party Germany
 Submission year 2010
 Reported year 2009
 Commitment period 1

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	4,43E+09	NO	NO	NO	NO	NO
Entity holding accounts	4,45E+08	NO	NO	40041182	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	215	NO	NO	100425	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	4,88E+09	NO	NO	40141607	NO	NO

Party Germany
 Submission year 2010
 Reported year 2009
 Commitment period 1

Table 2 (a). Annual internal transactions

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Article 6 issuance and conversion												
Party-verified projects		143492					143492		NO			
Independently verified projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired ICERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							1208	66	NO	193961	NO	NO
Sub-total		143492	NO				144700	66	NO	193961	NO	NO

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Retirement	NO	NO	NO	NO	NO	NO

Party Germany
 Submission year 2010
 Reported year 2009
 Commitment period 1

Add registry Delete registry No external transactions

Table 2 (b). Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Transfers and acquisitions												
CDM	NO	NO	NO	5143359	NO	NO	NO	NO	NO	NO	NO	NO
AT	7393578	NO	NO	230766	NO	NO	13019531	NO	NO	536489	NO	NO
BE	848325	NO	NO	51263	NO	NO	718127	108750	NO	532537	NO	NO
CH	NO	101050	NO	7133534	NO	NO	NO	5000	NO	2019291	NO	NO
CZ	18826792	NO	NO	NO	NO	NO	17596752	NO	NO	787680	NO	NO
DK	1.38E+08	NO	NO	5554592	NO	NO	53165659	NO	NO	752111	NO	NO
EE	11200	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
ES	1247232	NO	NO	634577	NO	NO	4259125	NO	NO	1434479	NO	NO
FI	216348	NO	NO	647501	NO	NO	1104454	NO	NO	1000	NO	NO
FR	51265216	NO	NO	1615260	NO	NO	48520037	NO	NO	4136788	NO	NO
GB	1.08E+08	262618	NO	19880191	NO	NO	1.67E+08	315544	NO	13647128	NO	NO
HU	1996511	NO	NO	30000	NO	NO	1778900	NO	NO	500643	NO	NO
IE	1500	NO	NO	45000	NO	NO	86000	NO	NO	NO	NO	NO
IT	1688973	NO	NO	15167	NO	NO	613326	NO	NO	177188	NO	NO
LT	103800	NO	NO	NO	NO	NO	1480	NO	NO	125000	NO	NO
LU	NO	NO	NO	NO	NO	NO	59000	NO	NO	64132	NO	NO
NL	38312596	302950	NO	10375617	NO	NO	40125559	111100	NO	1552666	NO	NO
NO	225930	NO	NO	125000	NO	NO	138377	NO	NO	NO	NO	NO
PL	2081669	1	NO	430002	NO	NO	657946	891	NO	210843	NO	NO
PT	115691	NO	NO	49464	NO	NO	3003316	NO	NO	1259	NO	NO
RO	162068	NO	NO	NO	NO	NO	NO	NO	NO	2500	NO	NO
SE	1734134	744	NO	205530	NO	NO	1134343	NO	NO	113001	NO	NO
SI	22686	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SK	69681	NO	NO	4800	NO	NO	1000	NO	NO	6981	NO	NO
UA	NO	52874	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	3.72E+08	720237	NO	52171623	NO	NO	3.53E+08	541285	NO	26601716	NO	NO

Additional information

Independently verified ERUs							NO					

Party Germany
 Submission year 2010
 Reported year 2009
 Commitment period 1

Table 3. Expiry, cancellation and replacement

Transaction or event type	Expiry, cancellation and requirement to replace		Replacement					
	Unit type		Unit type					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Temporary CERs (tCERs)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (ICERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired ICERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of ICERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Party Germany
 Submission year 2010
 Reported year 2009
 Commitment period 1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Party holding accounts	4.45E+09	NO	NO	24099433	NO	NO
Entity holding accounts	4.45E+08	322378	NO	41317695	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	1423	66	NO	294386	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	4.89E+09	322444	NO	65711514	NO	NO

Party Germany
Submission year 2010
Reported year 2009
Commitment period 1

Table 5 (a). Summary information on additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
Starting values	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Issuance pursuant to Article 3.7 and 3.8	4.87E+09						NO	NO	NO	NO		
Non-compliance cancellation												
Carry-over	NO	NO		NO								
Sub-total	4.87E+09			NO			NO	NO	NO	NO		
Annual transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	1.11E+08	NO	NO	48712902	NO	NO	1.04E+08	NO	NO	8671720	NO	NO
Year 2 (2009)	3.72E+08	863729	NO	52171623	NO	NO	3.53E+08	541361	NO	26795677	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	4.83E+08	863729	NO	1.01E+08	NO	NO	4.57E+08	541361	NO	35467397	NO	NO
Total	5.35E+09	863729	NO	1.01E+08	NO	NO	4.57E+08	541361	NO	35467397	NO	NO

Table 5 (b). Summary information on replacement

	Requirement for replacement		Replacement							
	Unit type		Unit type							
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs		
Previous CPs			NO	NO	NO	NO	NO	NO		
Year 1 (2008)	NO	NO	NO	NO	NO	NO	NO	NO		
Year 2 (2009)	NO	NO	NO	NO	NO	NO	NO	NO		
Year 3 (2010)	NO	NO	NO	NO	NO	NO	NO	NO		
Year 4 (2011)	NO	NO	NO	NO	NO	NO	NO	NO		
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO		
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO		
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO		
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO		
Total	NO	NO	NO	NO	NO	NO	NO	NO		

Table 5 (c). Summary information on retirement

Year	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO

Party Germany
Submission year 2010
Reported year 2009
Commitment period 1

Add transaction

Delete transaction

No corrective transaction

Table 6 (a). Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Add transaction

Delete transaction

No corrective transaction

Table 6 (b). Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement							
	Unit type		Unit type							
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs		

Add transaction

Delete transaction

No corrective transaction

Table 6 (c). Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

22.2.3 More detailed information about the national system, and about changes in the national system

All information has been provided in the preceding chapters.

22.2.4 Additional detailed information regarding the National Registries and accounting (bookkeeping) for Kyoto units

22.2.4.1 LIST OF TRANSACTIONS FORWARDING CER FROM THE CDM REGISTRY TO ACCOUNTS IN THE GERMAN REGISTRY

Transaction	Tme of transaction	Type	Source Account	Destination Account	Total
January 2009					
CDM-4848	12/01/2009 16:33	03-00	CDM-110-1000-0	DE-121-2095-0	21.002
CDM-4978	22/01/2009 11:03	03-00	CDM-110-1000-0	DE-121-1914-0	2.985
CDM-4961	22/01/2009 12:16	03-00	CDM-110-1000-0	DE-121-1914-0	10.818
CDM-5058	22/01/2009 15:20	03-00	CDM-110-1000-0	DE-121-1914-0	11.096
CDM-5043	22/01/2009 15:51	03-00	CDM-110-1000-0	DE-121-1914-0	4.542
CDM-5029	22/01/2009 16:29	03-00	CDM-110-1000-0	DE-121-1914-0	1.000
CDM-5012	22/01/2009 17:07	03-00	CDM-110-1000-0	DE-121-1914-0	757
CDM-4991	22/01/2009 18:21	03-00	CDM-110-1000-0	DE-121-1914-0	3.400
CDM-5098	23/01/2009 12:14	03-00	CDM-110-1000-0	DE-121-1914-0	1.362
CDM-5115	23/01/2009 18:21	03-00	CDM-110-1000-0	DE-121-1914-0	378.819
CDM-5127	29/01/2009 11:18	03-00	CDM-110-1000-0	DE-121-1914-0	134.254
February 2009					
CDM-5138	02/02/2009 15:32	03-00	CDM-110-1000-0	DE-121-1914-0	220.547
CDM-5154	02/02/2009 16:54	03-00	CDM-110-1000-0	DE-121-1914-0	248.038
CDM-5182	04/02/2009 10:34	03-00	CDM-110-1000-0	DE-121-1914-0	1.724
CDM-5161	04/02/2009 11:44	03-00	CDM-110-1000-0	DE-121-1914-0	480
CDM-5206	06/02/2009 12:05	03-00	CDM-110-1000-0	DE-121-1914-0	373.242
March 2009					
CDM-5383	11/03/2009 09:58	03-00	CDM-110-1000-0	DE-121-2095-0	19.301
CDM-5446	24/03/2009 16:21	03-00	CDM-110-1000-0	DE-121-1914-0	378.881
April 2009.					
CDM-5493	02/04/2009 18:49	03-00	CDM-110-1000-0	DE-121-1914-0	278.443
CDM-5506	07/04/2009 10:53	03-00	CDM-110-1000-0	DE-121-1989-0	1.055
CDM-5507	07/04/2009 11:06	03-00	CDM-110-1000-0	DE-121-2095-0	6.923
CDM-5523	08/04/2009 17:45	03-00	CDM-110-1000-0	DE-121-1914-0	208.373
CDM-5648	29/04/2009 18:34	03-00	CDM-110-1000-0	DE-121-1914-0	3.025
May 2009					
CDM-5735	04/05/2009 17:36	03-00	CDM-110-1000-0	DE-121-1914-0	74.943
CDM-5784	11/05/2009 12:45	03-00	CDM-110-1000-0	DE-121-1914-0	63.635
CDM-5765	11/05/2009 12:58	03-00	CDM-110-1000-0	DE-121-1914-0	2.690
CDM-5818	13/05/2009 17:48	03-00	CDM-110-1000-0	DE-121-1975-0	14.702
July 2009					
CDM-6106	13/07/2009 17:28	03-00	CDM-110-1000-0	DE-121-2095-0	39.160
CDM-6191	20/07/2009 17:30	03-00	CDM-110-1000-0	DE-121-2095-0	25.839
CDM-6210	22/07/2009 12:00	03-00	CDM-110-1000-0	DE-121-1914-0	157.833
CDM-6269	31/07/2009 09:35	03-00	CDM-110-1000-0	DE-121-2095-0	71.224
CDM-6279	31/07/2009 13:51	03-00	CDM-110-1000-0	DE-121-1914-0	776
August 2009					
CDM-6313	04/08/2009 11:22	03-00	CDM-110-1000-0	DE-121-1974-0	4.542
CDM-6323	04/08/2009 14:54	03-00	CDM-110-1000-0	DE-121-1974-0	11.096
CDM-6329	05/08/2009 11:46	03-00	CDM-110-1000-0	DE-121-1974-0	10.818
CDM-6333	05/08/2009 12:22	03-00	CDM-110-1000-0	DE-121-1914-0	301.064
CDM-6381	09/08/2009 14:13	03-00	CDM-110-1000-0	DE-121-1914-0	914
CDM-6379	09/08/2009 14:32	03-00	CDM-110-1000-0	DE-121-1914-0	163.184
CDM-6358	09/08/2009 14:39	03-00	CDM-110-1000-0	DE-121-1914-0	1.319
CDM-6411	10/08/2009 17:37	03-00	CDM-110-1000-0	DE-121-2227-0	42
CDM-6414	10/08/2009 17:38	03-00	CDM-110-1000-0	DE-121-2095-0	42
CDM-6415	11/08/2009 10:47	03-00	CDM-110-1000-0	DE-121-2227-0	126
CDM-6418	11/08/2009 10:49	03-00	CDM-110-1000-0	DE-121-2095-0	126
CDM-6423	11/08/2009 11:28	03-00	CDM-110-1000-0	DE-121-2227-0	198
CDM-6426	11/08/2009 11:31	03-00	CDM-110-1000-0	DE-121-2095-0	198
CDM-6419	11/08/2009 11:35	03-00	CDM-110-1000-0	DE-121-2227-0	235
CDM-6422	11/08/2009 11:36	03-00	CDM-110-1000-0	DE-121-2095-0	235
CDM-6440	12/08/2009 10:11	03-00	CDM-110-1000-0	DE-121-1914-0	2.444
CDM-6436	12/08/2009 10:23	03-00	CDM-110-1000-0	DE-121-2227-0	522
CDM-6433	12/08/2009 10:26	03-00	CDM-110-1000-0	DE-121-2095-0	522
CDM-6459	12/08/2009 10:29	03-00	CDM-110-1000-0	DE-121-1914-0	234.078
September 2009.					
CDM-6622	16/09/2009 12:37	03-00	CDM-110-1000-0	DE-121-2095-0	8.761
CDM-6663	24/09/2009 08:48	03-00	CDM-110-1000-0	DE-121-2095-0	209.621

Transaction	Tme of transaction	Type	Source Account	Destination Account	Total
CDM-6703	30/09/2009 10:59	03-00	CDM-110-1000-0	DE-121-1914-0	8.509
October 2009					
CDM-6744	08/10/2009 08:58	03-00	CDM-100-1004-0	DE-121-1974-0	36.049
CDM-6745	08/10/2009 09:02	03-00	CDM-100-1004-0	DE-121-1974-0	12.160
CDM-6746	08/10/2009 09:04	03-00	CDM-100-1004-0	DE-121-1974-0	11.950
CDM-6747	08/10/2009 09:04	03-00	CDM-100-1004-0	DE-121-1974-0	5.592
CDM-6748	08/10/2009 09:05	03-00	CDM-100-1004-0	DE-121-1974-0	11.164
CDM-6749	08/10/2009 09:09	03-00	CDM-100-1004-0	DE-121-1974-0	23.085
CDM-6755	09/10/2009 08:26	03-00	CDM-100-1004-0	DE-121-1974-0	11.935
CDM-6756	09/10/2009 08:27	03-00	CDM-100-1004-0	DE-121-1974-0	19.716
CDM-6757	09/10/2009 08:28	03-00	CDM-100-1004-0	DE-121-1974-0	16.064
CDM-6758	09/10/2009 08:30	03-00	CDM-100-1004-0	DE-121-1974-0	12.979
CDM-6759	09/10/2009 08:31	03-00	CDM-100-1004-0	DE-121-1974-0	12.879
CDM-6760	09/10/2009 08:32	03-00	CDM-100-1004-0	DE-121-1974-0	22.721
CDM-6761	09/10/2009 08:32	03-00	CDM-100-1004-0	DE-121-1974-0	3.706
CDM-6772	11/10/2009 09:39	03-00	CDM-100-1004-0	DE-121-1974-0	49.152
CDM-6773	11/10/2009 09:42	03-00	CDM-100-1004-0	DE-121-1974-0	22.989
CDM-6774	11/10/2009 09:44	03-00	CDM-100-1004-0	DE-121-1974-0	25.110
CDM-6775	11/10/2009 09:46	03-00	CDM-100-1004-0	DE-121-1974-0	2.749
CDM-6804	13/10/2009 10:52	03-00	CDM-110-1000-0	DE-121-2095-0	285
CDM-6785	13/10/2009 11:27	03-00	CDM-110-1000-0	DE-121-2227-0	285
CDM-6847	13/10/2009 17:22	03-00	CDM-100-1004-0	DE-121-1974-0	100.000
CDM-6894	14/10/2009 15:28	03-00	CDM-110-1000-0	DE-121-1914-0	1.925
CDM-6915	14/10/2009 16:13	03-00	CDM-110-1000-0	DE-121-1914-0	3.672
CDM-6955	16/10/2009 10:14	03-00	CDM-110-1000-0	DE-121-1914-0	2.444
CDM-6990	22/10/2009 14:18	03-00	CDM-110-1000-0	DE-121-1906-0	32.075
CDM-6999	23/10/2009 09:03	03-00	CDM-110-1000-0	DE-121-2095-0	16.914
November 2009					
CDM-7066	03/11/2009 13:34	03-00	CDM-110-1000-0	DE-121-2095-0	13.841
CDM-7182	20/11/2009 13:34	03-00	CDM-110-1000-0	DE-121-1975-0	12.702
CDM-7216	26/11/2009 12:03	03-00	CDM-110-1000-0	DE-121-1914-0	336.123
December 2009					
CDM-7286	08/12/2009 10:33	03-00	CDM-110-1000-0	DE-121-3591-0	20.101
CDM-7294	08/12/2009 17:18	03-00	CDM-110-1000-0	DE-121-1914-0	318.371
CDM-7306	08/12/2009 18:05	03-00	CDM-110-1000-0	DE-121-1914-0	235.539
CDM-7352	16/12/2009 06:30	03-00	CDM-110-1000-0	DE-121-2095-0	29.617
				Total	5.143.359

22.2.4.2 LIST OF RECONCILIATION RESULTS

Transaction	Snapshot date & Time	Reconciliation Status	Action Begin Date & Time	Action End Date & Time	Remarks
	01/01/2009 02:50	ITL Completed	2009-01-01 02:30:05.743	2009-01-01 02:50:33.72	
	02/01/2009 02:50	ITL Completed	2009-01-02 02:30:04.167	2009-01-02 02:50:28.473	
	03/01/2009 02:50	ITL Completed	2009-01-03 02:30:00.863	2009-01-03 02:50:27.13	
	04/01/2009 02:50	ITL Completed	2009-01-04 02:30:00.833	2009-01-04 02:50:34.48	
	05/01/2009 02:50	ITL Completed	2009-01-05 02:30:00.83	2009-01-05 02:50:25.9	
	06/01/2009 02:50	ITL Completed	2009-01-06 02:30:00.887	2009-01-06 02:50:26.037	
	07/01/2009 02:50	ITL Completed	2009-01-07 02:30:00.87	2009-01-07 02:50:28.313	
	08/01/2009 02:50	ITL Completed	2009-01-08 02:30:00.583	2009-01-08 02:50:27.113	
	09/01/2009 02:50	ITL Completed	2009-01-09 02:30:01.187	2009-01-09 02:50:27.513	
	10/01/2009 02:50	ITL Completed	2009-01-10 02:30:00.777	2009-01-10 02:50:30.043	
	11/01/2009 02:50	ITL Completed	2009-01-11 02:30:00.807	2009-01-11 02:50:25.557	
	12/01/2009 02:50	ITL Completed	2009-01-12 02:30:00.707	2009-01-12 02:50:28.16	
	13/01/2009 02:50	ITL Completed	2009-01-13 02:30:00.793	2009-01-13 02:50:30.45	
	14/01/2009 02:50	ITL Completed	2009-01-14 02:30:01.583	2009-01-14 02:50:30.1	
	15/01/2009 02:50	ITL Completed	2009-01-15 02:30:00.87	2009-01-15 02:50:31.23	
	16/01/2009 02:50	ITL Completed	2009-01-16 02:30:00.697	2009-01-16 02:50:28.993	
	17/01/2009 02:50	ITL Completed	2009-01-17 02:30:00.48	2009-01-17 02:50:31.683	
	18/01/2009 02:50	ITL Completed	2009-01-18 02:30:00.7	2009-01-18 02:50:30.53	
	19/01/2009 02:50	ITL Completed	2009-01-19 02:30:00.077	2009-01-19 02:50:24.623	
	20/01/2009 02:50	ITL Completed	2009-01-20 02:30:01.34	2009-01-20 02:50:25.577	
	21/01/2009 02:50	ITL Completed	2009-01-21 02:30:00.507	2009-01-21 02:50:27.71	
	22/01/2009 02:50	ITL Completed	2009-01-22 02:30:05.993	2009-01-22 02:50:28.15	
	23/01/2009 02:50	ITL Completed	2009-01-23 02:30:03.52	2009-01-23 02:50:26.333	
	24/01/2009 02:50	ITL Completed	2009-01-24 02:30:06.573	2009-01-24 02:50:28.323	
	24/01/2009 18:42	ITL Completed	2009-01-24 18:22:40.723	2009-01-24 18:43:12.31	
	25/01/2009 02:50	ITL Completed	2009-01-25 02:30:00.907	2009-01-25 02:50:25.86	
	26/01/2009 02:50	ITL Completed	2009-01-26 02:30:00.647	2009-01-26 02:50:25.477	
	27/01/2009 02:50	ITL Completed	2009-01-27 02:30:04.337	2009-01-27 02:50:32.037	
	28/01/2009 02:50	ITL Completed	2009-01-28 02:30:01.353	2009-01-28 02:50:29.837	
	29/01/2009 02:50	ITL Completed	2009-01-29 02:30:00.407	2009-01-29 02:50:28.093	
	30/01/2009 02:50	ITL Completed	2009-01-30 02:30:00.66	2009-01-30 02:50:24.503	
	31/01/2009 02:50	ITL Completed	2009-01-31 02:30:00.537	2009-01-31 02:50:31.77	
	01/02/2009 02:50	ITL Completed	2009-02-01 02:30:00.387	2009-02-01 02:50:27.34	
	02/02/2009 02:50	ITL Completed	2009-02-02 02:30:01.58	2009-02-02 02:50:28.58	
	03/02/2009 02:50	ITL Completed	2009-02-03 02:30:00.31	2009-02-03 02:50:27.997	
	04/02/2009 02:50	ITL Completed	2009-02-04 02:30:00.917	2009-02-04 02:50:28.247	
	05/02/2009 02:50	ITL Completed	2009-02-05 02:30:05.85	2009-02-05 02:50:28.96	
	06/02/2009 02:50	ITL Completed	2009-02-06 02:30:00.963	2009-02-06 02:50:28.463	
	07/02/2009 02:50	ITL Completed	2009-02-07 02:30:03.45	2009-02-07 02:50:24.467	
	08/02/2009 02:50	ITL Completed	2009-02-08 02:30:00.71	2009-02-08 02:50:27.477	
	09/02/2009 02:50	ITL Completed	2009-02-09 02:29:59.887	2009-02-09 02:50:25.95	
	10/02/2009 02:50	ITL Completed	2009-02-10 02:30:01.087	2009-02-10 02:50:30.323	
	11/02/2009 02:50	ITL Completed	2009-02-11 02:30:00.053	2009-02-11 02:50:27.35	
	12/02/2009 02:50	ITL Completed	2009-02-12 02:30:02.407	2009-02-12 02:50:30.74	
	13/02/2009 02:50	ITL Completed	2009-02-13 02:30:00.523	2009-02-13 02:50:26.343	
	14/02/2009 02:50	ITL Completed	2009-02-14 02:30:05.833	2009-02-14 02:50:29.373	
	15/02/2009 02:50	ITL Completed	2009-02-15 02:29:58.763	2009-02-15 02:50:27.297	
	16/02/2009 02:50	ITL Completed	2009-02-16 02:30:05.117	2009-02-16 02:50:24.657	
	17/02/2009 02:50	ITL Completed	2009-02-17 02:30:00.277	2009-02-17 02:50:28.19	
	18/02/2009 02:50	ITL Completed	2009-02-18 02:30:01.0	2009-02-18 02:50:31.57	
	19/02/2009 02:50	ITL Completed	2009-02-19 02:30:05.53	2009-02-19 02:50:27.66	
	20/02/2009 02:50	ITL Completed	2009-02-20 02:30:00.667	2009-02-20 02:50:28.797	
	21/02/2009 02:50	ITL Completed	2009-02-21 02:30:05.123	2009-02-21 02:50:33.63	
	22/02/2009 02:50	ITL Completed	2009-02-22 02:30:01.053	2009-02-22 02:50:27.31	
	23/02/2009 02:50	ITL Completed	2009-02-23 02:30:00.657	2009-02-23 02:50:29.913	
	24/02/2009 02:50	ITL Completed	2009-02-24 02:30:00.357	2009-02-24 02:50:29.993	
	25/02/2009 02:50	ITL Completed	2009-02-25 02:30:01.067	2009-02-25 02:50:32.09	
	26/02/2009 02:50	ITL Completed	2009-02-26 02:30:01.347	2009-02-26 02:50:31.93	
	27/02/2009 02:50	ITL Completed	2009-02-27 02:30:01.127	2009-02-27 02:50:31.777	
	28/02/2009 02:50	ITL Completed	2009-02-28 02:30:00.813	2009-02-28 02:50:30.517	
	01/03/2009 02:50	ITL Completed	2009-03-01 02:30:06.107	2009-03-01 02:50:30.12	
	02/03/2009 02:50	ITL Completed	2009-03-02 02:30:01.053	2009-03-02 02:50:34.03	
	03/03/2009 02:50	ITL Completed	2009-03-03 02:30:00.617	2009-03-03 02:50:35.98	
	04/03/2009 02:50	ITL Completed	2009-03-04 02:30:03.49	2009-03-04 02:50:31.89	

Transaction	Snapshot date & Time	Reconciliation Status	Action Begin Date & Time	Action End Date & Time	Remarks
	05/03/2009 02:50	ITL Completed	2009-03-05 02:30:00.487	2009-03-05 02:50:29.053	
	06/03/2009 02:50	ITL Completed	2009-03-06 02:30:00.607	2009-03-06 02:50:28.747	
DE10012256	07/03/2009 02:50	ITL Completed with Manual Intervention	2009-03-07 10:31:00.307	2009-03-07 10:31:26.693	There was a failed scheduled reconciliation: DE10012256 as a result from a problem with the ITL last night.
	07/03/2009 19:28	ITL Completed	2009-03-07 19:08:51.253	2009-03-07 19:29:24.51	
	08/03/2009 02:50	ITL Completed	2009-03-08 02:30:00.113	2009-03-08 02:50:30.253	
	09/03/2009 02:50	ITL Completed	2009-03-09 02:30:00.363	2009-03-09 02:50:27.48	
	10/03/2009 02:50	ITL Completed	2009-03-10 02:30:04.373	2009-03-10 02:50:34.49	
	11/03/2009 02:50	ITL Completed	2009-03-11 02:30:05.917	2009-03-11 02:50:37.12	
DE10013032	12/03/2009 11:17	ITL Completed with Manual Intervention	2009-03-12 10:57:11.517	2009-03-12 10:57:11.533	OSD000002873541 DE-100-3-0 1-1 EUA: 6.475.963 DE-120-1690-0 1-1 EUA: 131.055
DE10013045	12/03/2009 02:50	ITL Completed with Manual Intervention	2009-03-12 02:30:00.48	2009-03-12 10:58:00.0	Old recon not stopped.
DE10013144	12/03/2009 11:28	ITL Completed with Manual Intervention	2009-03-12 11:08:23.823	2009-03-12 11:54:00.0	CITL can not see a new reconciliation has been started. DE stopped manually.
	12/03/2009 12:21	ITL Completed	2009-03-12 12:01:24.617	2009-03-12 12:21:51.423	
	13/03/2009 02:50	ITL Completed	2009-03-13 02:30:00.67	2009-03-13 02:50:31.223	
	14/03/2009 02:50	ITL Completed	2009-03-14 02:30:01.063	2009-03-14 02:50:33.75	
	15/03/2009 02:50	ITL Completed	2009-03-15 02:30:00.633	2009-03-15 02:50:33.047	
	16/03/2009 02:50	ITL Completed	2009-03-16 02:30:03.807	2009-03-16 02:50:30.673	
	17/03/2009 02:50	ITL Completed	2009-03-17 02:30:05.943	2009-03-17 02:50:29.483	
	18/03/2009 02:50	ITL Completed	2009-03-18 02:30:00.76	2009-03-18 02:50:37.57	
	19/03/2009 02:50	ITL Completed	2009-03-19 02:30:05.5	2009-03-19 02:50:40.813	
	20/03/2009 02:50	ITL Completed	2009-03-20 02:30:03.89	2009-03-20 02:50:29.483	
DE10013296	21/03/2009 02:50	ITL Completed	2009-03-21 02:30:04.507	2009-03-21 02:50:39.123	
DE10013601	21/03/2009 17:02	ITL Completed with Manual Intervention	2009-03-21 16:42:02.9	2009-03-21 16:42:02.913	OSD000002891916
DE10013602	21/03/2009 14:52	ITL Completed with Manual Intervention	2009-03-21 14:32:47.413	2009-03-23 09:34:00.0	DE not online; a mistake from ITL
DE10013802	23/03/2009 10:22	ITL Completed	2009-03-23 10:02:28.64	2009-03-23 10:23:04.733	
	24/03/2009 02:50	ITL Completed	2009-03-24 02:30:00.237	2009-03-24 02:50:37.033	
	25/03/2009 02:50	ITL Completed	2009-03-25 02:29:59.683	2009-03-25 02:50:35.243	
	26/03/2009 02:50	ITL Completed	2009-03-26 02:30:03.703	2009-03-26 02:50:35.743	
	27/03/2009 02:50	ITL Completed	2009-03-27 02:30:01.587	2009-03-27 02:50:31.837	
	28/03/2009 02:50	ITL Completed	2009-03-28 02:30:03.96	2009-03-28 02:50:38.52	
	29/03/2009 03:50	ITL Completed	2009-03-29 03:30:03.547	2009-03-29 03:50:41.08	
	30/03/2009 03:50	ITL Completed	2009-03-30 03:30:03.337	2009-03-30 03:50:32.11	
	31/03/2009 03:50	ITL Completed	2009-03-31 03:30:00.987	2009-03-31 03:50:37.02	
	01/04/2009 03:50	ITL Completed	2009-04-01 03:30:01.807	2009-04-01 03:50:35.067	
	02/04/2009 03:50	ITL Completed	2009-04-02 03:30:04.723	2009-04-02 03:50:30.683	
	03/04/2009 03:50	ITL Completed	2009-04-03 03:30:04.133	2009-04-03 03:50:34.5	
	04/04/2009 03:50	ITL Completed	2009-04-04 03:30:03.03	2009-04-04 03:50:39.13	
	05/04/2009 03:50	ITL Completed	2009-04-05 03:30:00.853	2009-04-05 03:50:50.477	
	06/04/2009 03:50	ITL Completed	2009-04-06 03:30:00.867	2009-04-06 03:50:32.93	
	07/04/2009 03:50	ITL Completed	2009-04-07 03:30:00.807	2009-04-07 03:50:33.77	
	08/04/2009 03:50	ITL Completed	2009-04-08 03:30:05.42	2009-04-08 03:50:35.677	
	09/04/2009 03:50	ITL Completed	2009-04-09 03:30:02.543	2009-04-09 03:50:36.167	
	10/04/2009 03:50	ITL Completed	2009-04-10 03:30:00.487	2009-04-10 03:50:35.537	
	11/04/2009 03:50	ITL Completed	2009-04-11 03:30:00.413	2009-04-11 03:50:35.56	
	12/04/2009 03:50	ITL Completed	2009-04-12 03:30:03.817	2009-04-12 03:50:58.113	
	13/04/2009 03:50	ITL Completed	2009-04-13 03:30:00.397	2009-04-13 03:50:34.857	
	14/04/2009 03:50	ITL Completed	2009-04-14 03:30:00.677	2009-04-14 03:50:34.9	
	15/04/2009 03:50	ITL Completed	2009-04-15 03:30:00.533	2009-04-15 03:50:36.197	
	16/04/2009 03:50	ITL Completed	2009-04-16 03:30:00.427	2009-04-16 03:50:36.123	
	17/04/2009 03:50	ITL Completed	2009-04-17 03:30:01.577	2009-04-17 03:50:42.55	
	18/04/2009 03:50	ITL Completed	2009-04-18 03:30:00.39	2009-04-18 03:50:38.193	
	19/04/2009 03:50	ITL Completed	2009-04-19 03:29:59.77	2009-04-19 03:50:33.903	
	20/04/2009 03:50	ITL Completed	2009-04-20 03:30:03.103	2009-04-20 03:50:28.877	
	21/04/2009 03:50	ITL Completed	2009-04-21 03:29:59.657	2009-04-21 03:50:35.937	
	22/04/2009 03:50	ITL Completed	2009-04-22 03:30:00.177	2009-04-22 03:50:38.187	

Transaction	Snapshot date & Time	Reconciliation Status	Action Begin Date & Time	Action End Date & Time	Remarks
	23/04/2009 03:50	ITL Completed	2009-04-23 03:30:03.457	2009-04-23 03:50:41.997	
	24/04/2009 03:50	ITL Completed	2009-04-24 03:30:01.357	2009-04-24 03:50:37.927	
	24/04/2009 21:09	ITL Completed	2009-04-24 20:49:12.513	2009-04-24 21:09:49.94	
	25/04/2009 03:50	ITL Completed	2009-04-25 03:30:01.957	2009-04-25 03:50:33.13	
	26/04/2009 03:50	ITL Completed	2009-04-26 03:30:02.757	2009-04-26 03:50:38.02	
	27/04/2009 03:50	ITL Completed	2009-04-27 03:30:06.827	2009-04-27 03:50:38.077	
	28/04/2009 03:50	ITL Completed	2009-04-28 03:30:05.297	2009-04-28 03:50:45.817	
	29/04/2009 03:50	ITL Completed	2009-04-29 03:30:09.05	2009-04-29 03:50:36.463	
	30/04/2009 03:50	ITL Completed	2009-04-30 03:30:11.993	2009-04-30 03:50:45.29	
	01/05/2009 02:30	ITL Completed	2009-05-01 02:10:10.643	2009-05-01 02:30:45.097	
	02/05/2009 03:50	ITL Completed	2009-05-02 03:30:08.767	2009-05-02 03:50:39.133	
	03/05/2009 03:50	ITL Completed	2009-05-03 03:30:10.473	2009-05-03 03:50:44.893	
	04/05/2009 03:50	ITL Completed	2009-05-04 03:30:11.13	2009-05-04 03:50:45.207	
	05/05/2009 03:50	ITL Completed	2009-05-05 03:30:00.87	2009-05-05 03:50:33.517	
	06/05/2009 03:50	ITL Completed	2009-05-06 03:30:00.65	2009-05-06 03:50:39.41	
	07/05/2009 03:50	ITL Completed	2009-05-07 03:30:00.67	2009-05-07 03:50:38.77	
	08/05/2009 03:50	ITL Completed	2009-05-08 03:30:05.287	2009-05-08 03:50:34.477	
	09/05/2009 03:50	ITL Completed	2009-05-09 03:30:01.513	2009-05-09 03:50:34.82	
	10/05/2009 03:50	ITL Completed	2009-05-10 03:30:00.527	2009-05-10 03:50:23.797	
	11/05/2009 03:50	ITL Completed	2009-05-11 03:30:03.673	2009-05-11 03:50:22.54	
	12/05/2009 03:50	ITL Completed	2009-05-12 03:30:03.673	2009-05-12 03:50:33.073	
	13/05/2009 03:50	ITL Completed	2009-05-13 03:30:04.697	2009-05-13 03:50:33.103	
	14/05/2009 03:50	ITL Completed	2009-05-14 03:30:01.287	2009-05-14 03:50:35.12	
	15/05/2009 03:50	ITL Completed	2009-05-15 03:30:04.283	2009-05-15 03:50:32.43	
	16/05/2009 03:50	ITL Completed	2009-05-16 03:29:58.9	2009-05-16 03:50:31.797	
	16/05/2009 20:05	ITL Completed	2009-05-16 19:44:59.317	2009-05-16 20:05:31.817	
	17/05/2009 03:50	ITL Completed	2009-05-17 03:29:57.207	2009-05-17 03:50:30.05	
	18/05/2009 03:50	ITL Completed	2009-05-18 03:30:00.357	2009-05-18 03:50:32.58	
	19/05/2009 03:50	ITL Completed	2009-05-19 03:30:00.217	2009-05-19 03:50:31.28	
	20/05/2009 03:50	ITL Completed	2009-05-20 03:30:00.523	2009-05-20 03:50:37.227	
	21/05/2009 03:50	ITL Completed	2009-05-21 03:30:00.963	2009-05-21 03:50:28.847	
	22/05/2009 03:50	ITL Completed	2009-05-22 03:30:00.58	2009-05-22 03:50:29.433	
	23/05/2009 03:50	ITL Completed	2009-05-23 03:30:00.823	2009-05-23 03:50:30.52	
	24/05/2009 03:50	ITL Completed	2009-05-24 03:30:00.75	2009-05-24 03:50:31.24	
	25/05/2009 03:50	ITL Completed	2009-05-25 03:30:00.217	2009-05-25 03:50:29.647	
	26/05/2009 03:50	ITL Completed	2009-05-26 03:30:00.85	2009-05-26 03:50:30.663	
	27/05/2009 03:50	ITL Completed	2009-05-27 03:30:02.563	2009-05-27 03:50:30.057	
	28/05/2009 03:50	ITL Completed	2009-05-28 03:30:04.617	2009-05-28 03:50:29.36	
	29/05/2009 03:50	ITL Completed	2009-05-29 03:30:05.623	2009-05-29 03:50:27.13	
	30/05/2009 03:50	ITL Completed	2009-05-30 03:30:03.813	2009-05-30 03:50:31.25	
	30/05/2009 23:35	ITL Completed	2009-05-30 23:15:11.807	2009-05-30 23:35:42.69	
	31/05/2009 03:50	ITL Completed	2009-05-31 03:29:59.88	2009-05-31 03:50:21.887	
	01/06/2009 03:50	ITL Completed	2009-06-01 03:30:05.25	2009-06-01 03:50:30.513	
	02/06/2009 03:50	ITL Completed	2009-06-02 03:30:04.87	2009-06-02 03:50:28.98	
	03/06/2009 03:50	ITL Completed	2009-06-03 03:30:00.74	2009-06-03 03:50:29.113	
	04/06/2009 03:50	ITL Completed	2009-06-04 03:30:00.573	2009-06-04 03:50:26.087	
	05/06/2009 03:50	ITL Completed	2009-06-05 03:30:04.053	2009-06-05 03:50:25.693	
	06/06/2009 03:50	ITL Completed	2009-06-06 03:30:00.927	2009-06-06 03:50:30.6	
	07/06/2009 03:50	ITL Completed	2009-06-07 03:29:59.743	2009-06-07 03:50:29.377	
	08/06/2009 03:50	ITL Completed	2009-06-08 03:30:00.227	2009-06-08 03:50:27.99	
	09/06/2009 03:50	ITL Completed	2009-06-09 03:30:01.21	2009-06-09 03:50:27.593	
	10/06/2009 03:50	ITL Completed	2009-06-10 03:30:01.163	2009-06-10 03:50:32.693	
	11/06/2009 03:50	ITL Completed	2009-06-11 03:30:00.747	2009-06-11 03:50:31.987	
	12/06/2009 03:50	ITL Completed	2009-06-12 03:30:00.83	2009-06-12 03:50:29.993	
	13/06/2009 03:50	ITL Completed	2009-06-13 03:30:00.047	2009-06-13 03:50:28.24	
	14/06/2009 03:50	ITL Completed	2009-06-14 03:30:03.273	2009-06-14 03:50:23.96	
	15/06/2009 03:50	ITL Completed	2009-06-15 03:30:00.147	2009-06-15 03:50:27.013	
	16/06/2009 03:50	ITL Completed	2009-06-16 03:30:00.957	2009-06-16 03:50:33.517	
	17/06/2009 03:50	ITL Completed	2009-06-17 03:30:01.183	2009-06-17 03:50:31.557	
	18/06/2009 03:50	ITL Completed	2009-06-18 03:30:05.477	2009-06-18 03:50:31.337	
	18/06/2009 16:30	ITL Completed	2009-06-18 16:10:04.81	2009-06-18 16:30:37.013	
	19/06/2009 03:50	ITL Completed	2009-06-19 03:30:03.037	2009-06-19 03:50:32.373	
	20/06/2009 03:50	ITL Completed	2009-06-20 03:30:04.303	2009-06-20 03:50:33.88	
	21/06/2009 03:50	ITL Completed	2009-06-21 03:30:01.25	2009-06-21 03:50:34.263	
	22/06/2009 03:50	ITL Completed	2009-06-22 03:30:00.713	2009-06-22 03:50:30.783	
	23/06/2009 03:50	ITL Completed	2009-06-23 03:30:03.34	2009-06-23 03:50:33.55	

Transaction	Snapshot date & Time	Reconciliation Status	Action Begin Date & Time	Action End Date & Time	Remarks
	24/06/2009 03:50	ITL Completed	2009-06-24 03:30:00.343	2009-06-24 03:50:33.23	
	25/06/2009 03:50	ITL Completed	2009-06-25 03:30:00.147	2009-06-25 03:50:25.873	
	26/06/2009 03:50	ITL Completed	2009-06-26 03:30:02.88	2009-06-26 03:50:23.7	
	27/06/2009 03:50	ITL Completed	2009-06-27 03:30:00.82	2009-06-27 03:50:25.753	
	28/06/2009 03:50	ITL Completed	2009-06-28 03:30:04.013	2009-06-28 03:50:45.137	
	29/06/2009 03:50	ITL Completed	2009-06-29 03:30:00.707	2009-06-29 03:50:25.567	
	30/06/2009 03:50	ITL Completed	2009-06-30 03:30:00.557	2009-06-30 03:50:27.65	
	01/07/2009 03:50	ITL Completed	2009-07-01 03:30:05.133	2009-07-01 03:50:45.337	
	02/07/2009 03:50	ITL Completed	2009-07-02 03:30:03.533	2009-07-02 03:50:27.44	
	03/07/2009 03:50	ITL Completed	2009-07-03 03:30:03.85	2009-07-03 03:50:26.857	
	04/07/2009 03:50	ITL Completed	2009-07-04 03:30:00.243	2009-07-04 03:50:26.767	
	04/07/2009 18:05	ITL Completed	2009-07-04 17:45:37.283	2009-07-04 18:06:29.327	
	05/07/2009 03:50	ITL Completed	2009-07-05 03:30:00.583	2009-07-05 03:50:45.277	
	06/07/2009 03:50	ITL Completed	2009-07-06 03:29:58.853	2009-07-06 03:50:22.07	
	07/07/2009 03:50	ITL Completed	2009-07-07 03:29:59.173	2009-07-07 03:50:22.597	
	08/07/2009 03:50	ITL Completed	2009-07-08 03:30:01.183	2009-07-08 03:50:28.347	
	09/07/2009 03:50	ITL Completed	2009-07-09 03:30:03.707	2009-07-09 03:50:51.197	
	10/07/2009 03:50	ITL Completed	2009-07-10 03:30:00.473	2009-07-10 03:50:25.31	
	11/07/2009 03:50	ITL Completed	2009-07-11 03:30:04.63	2009-07-11 03:50:25.713	
	12/07/2009 03:50	ITL Completed	2009-07-12 03:30:00.907	2009-07-12 03:50:27.603	
	13/07/2009 03:50	ITL Completed	2009-07-13 03:30:01.193	2009-07-13 03:50:30.12	
	14/07/2009 03:50	ITL Completed	2009-07-14 03:30:01.217	2009-07-14 03:50:26.467	
	15/07/2009 03:50	ITL Completed	2009-07-15 03:30:01.09	2009-07-15 03:50:24.373	
	16/07/2009 03:50	ITL Completed	2009-07-16 03:30:00.62	2009-07-16 03:50:22.73	
	17/07/2009 03:50	ITL Completed	2009-07-17 03:30:06.373	2009-07-17 03:50:23.833	
	18/07/2009 03:50	ITL Completed	2009-07-18 03:30:04.913	2009-07-18 03:50:23.31	
	19/07/2009 03:50	ITL Completed	2009-07-19 03:30:04.773	2009-07-19 03:50:24.95	
	20/07/2009 03:50	ITL Completed	2009-07-20 03:30:04.577	2009-07-20 03:50:25.333	
	21/07/2009 03:50	ITL Completed	2009-07-21 03:30:05.08	2009-07-21 03:50:48.383	
	22/07/2009 03:50	ITL Completed	2009-07-22 03:29:59.66	2009-07-22 03:50:22.263	
	23/07/2009 03:50	ITL Completed	2009-07-23 03:30:00.797	2009-07-23 03:50:25.993	
	24/07/2009 03:50	ITL Completed	2009-07-24 03:30:00.397	2009-07-24 03:50:30.99	
	25/07/2009 03:50	ITL Completed	2009-07-25 03:30:01.373	2009-07-25 03:50:53.847	
	26/07/2009 03:50	ITL Completed	2009-07-26 03:30:01.333	2009-07-26 03:50:46.84	
	27/07/2009 03:50	ITL Completed	2009-07-27 03:30:01.517	2009-07-27 03:50:23.703	
	28/07/2009 03:50	ITL Completed	2009-07-28 03:30:07.88	2009-07-28 03:50:25.037	
	29/07/2009 03:50	ITL Completed	2009-07-29 03:30:00.987	2009-07-29 03:50:24.073	
	30/07/2009 03:50	ITL Completed	2009-07-30 03:30:01.007	2009-07-30 03:50:24.42	
	31/07/2009 03:50	ITL Completed	2009-07-31 03:30:01.647	2009-07-31 03:50:25.32	
	01/08/2009 03:50	ITL Completed	2009-08-01 03:30:04.14	2009-08-01 03:50:49.427	
	02/08/2009 03:50	ITL Completed	2009-08-02 03:30:00.96	2009-08-02 03:50:46.56	
	03/08/2009 03:50	ITL Completed	2009-08-03 03:30:03.96	2009-08-03 03:50:44.123	
	04/08/2009 03:50	ITL Completed	2009-08-04 03:30:05.743	2009-08-04 03:50:44.773	
	05/08/2009 03:50	ITL Completed	2009-08-05 03:30:01.117	2009-08-05 03:50:42.787	
	06/08/2009 03:50	ITL Completed	2009-08-06 03:30:01.16	2009-08-06 03:50:24.44	
	07/08/2009 03:50	ITL Completed	2009-08-07 03:30:05.247	2009-08-07 03:50:26.387	
	08/08/2009 03:50	ITL Completed	2009-08-08 03:30:00.96	2009-08-08 03:50:49.533	
	09/08/2009 03:50	ITL Completed	2009-08-09 03:30:01.187	2009-08-09 03:50:48.967	
DE10020256	10/08/2009 03:50	ITL Completed with Manual Intervention	2009-08-10 03:30:01.13	2009-08-11 09:45:00.0	ITL: The new Common Operational Procedure for Reconciliations instructs us that the ITL should manually close any reconciliation which is stuck for 1 hour in a status of Confirmed, Initiated or Validated and immediately commence a new one. However this can only be done after some registries have been advised firstly to close the stuck reconciliation at their end and have confirmed to us that it has been done. We would therefore ask that you please conform to us your current software, version and whether it is necessary for you to close the reconciliation in your own registry before we can start a new one in the ITL?
	13/08/2009 03:50	ITL Completed	2009-08-13 03:30:05.023	2009-08-13 03:50:24.307	
	14/08/2009 03:50	ITL Completed	2009-08-14 03:30:00.547	2009-08-14 03:50:27.077	
	15/08/2009 03:50	ITL Completed	2009-08-15 03:30:03.78	2009-08-15 03:50:49.343	
DE10020429	16/08/2009 03:50	ITL Completed	2009-08-16 03:30:03.667	2009-08-17 16:25:00.0	INC000000174339

Transaction	Snapshot date & Time	Reconciliation Status	Action Begin Date & Time	Action End Date & Time	Remarks
		with Manual Intervention			ITL: We have a reconciliation (DE10020429) stuck in Validated in the PROD environment. Can you close it your side so that we can run another one?
DE10020545	17/08/2009 17:00	ITL Completed	2009-08-17 16:40:13.803	2009-08-17 17:00:41.187	
	18/08/2009 03:50	ITL Completed	2009-08-18 03:30:05.063	2009-08-18 03:50:25.19	
	19/08/2009 03:50	ITL Completed	2009-08-19 03:30:00.57	2009-08-19 03:50:24.68	
	20/08/2009 03:50	ITL Completed	2009-08-20 03:30:00.993	2009-08-20 03:50:23.597	
	21/08/2009 03:50	ITL Completed	2009-08-21 03:30:01.427	2009-08-21 03:50:25.303	
	22/08/2009 03:50	ITL Completed	2009-08-22 03:30:03.463	2009-08-22 03:50:47.877	
	23/08/2009 03:50	ITL Completed	2009-08-23 03:30:03.713	2009-08-23 03:50:50.573	
DE10020753	24/08/2009 03:50	ITL Completed with Manual Intervention	2009-08-24 03:30:00.413	2009-08-24 17:53:00.0	INC000000192106 Problem CITL; ITL: Susanne/CITL> I have closed this reconciliation in the ITL, can you confirm it has been closed in the CITL?
	24/08/2009 18:36	ITL Completed	2009-08-24 18:16:35.097	2009-08-24 18:36:58.43	
	25/08/2009 03:50	ITL Completed	2009-08-25 03:30:00.607	2009-08-25 03:50:24.16	
	26/08/2009 03:50	ITL Completed	2009-08-26 03:30:04.393	2009-08-26 03:50:26.447	
	27/08/2009 03:50	ITL Completed	2009-08-27 03:30:04.037	2009-08-27 03:50:45.62	
	28/08/2009 03:50	ITL Completed	2009-08-28 03:30:04.693	2009-08-28 03:50:27.967	
	29/08/2009 03:50	ITL Completed	2009-08-29 03:30:04.593	2009-08-29 03:50:52.98	
	29/08/2009 11:05	ITL Completed	2009-08-29 10:45:00.893	2009-08-29 11:06:20.877	
	30/08/2009 03:50	ITL Completed	2009-08-30 03:30:00.747	2009-08-30 03:51:08.913	
DE10021085	31/08/2009 03:50	ITL Completed with Manual Intervention	2009-08-31 03:30:00.657	2009-08-31 18:21:00.0	INC000000210317 Problem CITL
DE10021130	01/09/2009 03:50	ITL Completed with Manual Intervention	2009-09-01 03:30:04.947	2009-09-01 09:25:00.0	INC000000212257 Problem CITL
DE10021152	01/09/2009 10:35	ITL Completed	2009-09-01 10:15:59.987	2009-09-01 10:36:24.22	
	02/09/2009 03:50	ITL Completed	2009-09-02 03:30:00.737	2009-09-02 03:50:27.423	
	03/09/2009 03:50	ITL Completed	2009-09-03 03:30:04.287	2009-09-03 03:50:29.537	
	04/09/2009 03:50	ITL Completed	2009-09-04 03:30:01.277	2009-09-04 03:50:47.417	
	05/09/2009 03:50	ITL Completed	2009-09-05 03:29:59.947	2009-09-05 03:51:08.163	
	06/09/2009 03:50	ITL Completed	2009-09-06 03:30:00.653	2009-09-06 03:51:26.937	
DE10021358	07/09/2009 03:50	ITL Completed with Manual Intervention	2009-09-07 03:30:00.893	2009-09-07 11:52:00.0	INC000000228593 Problem CITL
	07/09/2009 12:59	ITL Completed	2009-09-07 12:39:39.883	2009-09-07 13:00:04.937	
	08/09/2009 03:50	ITL Completed	2009-09-08 03:30:00.637	2009-09-08 03:50:25.157	
	09/09/2009 03:50	ITL Completed	2009-09-09 03:30:01.027	2009-09-09 03:50:30.017	
	10/09/2009 03:50	ITL Completed	2009-09-10 03:30:00.807	2009-09-10 03:50:25.387	
	11/09/2009 03:50	ITL Completed	2009-09-11 03:30:01.693	2009-09-11 03:50:28.627	
	12/09/2009 03:50	ITL Completed	2009-09-12 03:30:03.647	2009-09-12 03:50:52.357	
	13/09/2009 03:50	ITL Completed	2009-09-13 03:30:00.32	2009-09-13 03:50:27.41	
	14/09/2009 03:50	ITL Completed	2009-09-14 03:30:05.21	2009-09-14 07:51:26.153	
	15/09/2009 03:50	ITL Completed	2009-09-15 03:30:00.843	2009-09-15 03:50:24.443	
	16/09/2009 03:50	ITL Completed	2009-09-16 03:30:00.97	2009-09-16 03:50:28.207	
	17/09/2009 03:50	ITL Completed	2009-09-17 03:30:05.057	2009-09-17 07:51:29.04	
	18/09/2009 03:50	ITL Completed	2009-09-18 03:30:04.483	2009-09-18 03:50:23.617	
	19/09/2009 03:50	ITL Completed	2009-09-19 03:29:59.647	2009-09-19 03:50:48.713	
	20/09/2009 03:50	ITL Completed	2009-09-20 03:30:01.257	2009-09-20 03:50:26.437	
	21/09/2009 03:50	ITL Completed	2009-09-21 03:29:59.633	2009-09-21 03:50:24.17	
	22/09/2009 03:50	ITL Completed	2009-09-22 03:30:00.83	2009-09-22 03:50:25.11	
	23/09/2009 03:50	ITL Completed	2009-09-23 03:30:00.597	2009-09-23 03:50:26.633	
	24/09/2009 03:50	ITL Completed	2009-09-24 03:30:00.123	2009-09-24 03:50:24.193	
DE10022066	25/09/2009 03:50	ITL Completed with Manual Intervention	2009-09-25 03:30:00.84	2009-09-25 10:39:00.0	Status "ITL Start Request Denied".
DE10022093	25/09/2009 09:48	ITL Completed with Manual Intervention	2009-09-25 09:28:19.76	2009-09-25 09:28:19.79	New start from ITL, DE not stopped manually
DE10022099	25/09/2009 10:19	ITL Completed with Manual Intervention	2009-09-25 09:59:31.257	2009-09-25 09:59:31.273	All recon stopped manually
DE10022106	25/09/2009 11:05	ITL Completed	2009-09-25 10:45:38.187	2009-09-25 11:06:05.277	

Transaction	Snapshot date & Time	Reconciliation Status	Action Begin Date & Time	Action End Date & Time	Remarks
	26/09/2009 03:50	ITL Completed	2009-09-26 03:30:04.747	2009-09-26 03:50:49.1	
	26/09/2009 18:01	ITL Completed	2009-09-26 17:41:28.657	2009-09-26 18:02:11.453	
	27/09/2009 03:50	ITL Completed	2009-09-27 03:30:01.0	2009-09-27 03:50:30.017	
	28/09/2009 03:50	ITL Completed	2009-09-28 03:30:01.14	2009-09-28 03:50:25.297	
	29/09/2009 03:50	ITL Completed	2009-09-29 03:30:00.48	2009-09-29 03:50:24.967	
	30/09/2009 03:50	ITL Completed	2009-09-30 03:30:00.39	2009-09-30 03:50:25.943	
	01/10/2009 03:50	ITL Completed	2009-10-01 03:30:01.173	2009-10-01 03:50:25.42	
DE10022564	02/10/2009 03:50	ITL Completed with Manual Intervention	2009-10-02 03:30:01.5	2009-10-02 15:39:00.0	INC000000302085 External Transfer DK499890 stuck in Accepted
DE10022451	02/10/2009 16:21	ITL Completed	2009-10-02 16:01:50.067	2009-10-02 16:22:15.86	
	03/10/2009 03:50	ITL Completed	2009-10-03 03:30:01.013	2009-10-03 03:50:51.833	
	03/10/2009 16:26	ITL Completed	2009-10-03 16:06:57.17	2009-10-03 16:27:46.893	
DE10022746	04/10/2009 03:50	ITL Completed with Manual Intervention	2009-10-04 03:30:05.527	2009-10-05 09:04:00.0	CITL losing communications with the ITL
DE10022782	05/10/2009 03:50	ITL Start Request Denied	2009-10-05 03:30:00.533	2009-10-05 03:30:00.55	INC000000309224/ INC000000308303 CITL losing communications with the ITL
	06/10/2009 03:50	ITL Completed	2009-10-06 03:30:04.947	2009-10-06 03:50:26.86	
	07/10/2009 03:50	ITL Completed	2009-10-07 03:30:04.913	2009-10-07 03:50:29.25	
	08/10/2009 03:50	ITL Completed	2009-10-08 03:30:00.68	2009-10-08 03:50:29.233	
	09/10/2009 03:50	ITL Completed	2009-10-09 03:30:01.403	2009-10-09 03:50:26.997	
	10/10/2009 03:50	ITL Completed	2009-10-10 03:30:05.767	2009-10-10 03:50:29.907	
	11/10/2009 03:50	ITL Completed	2009-10-11 03:30:00.417	2009-10-11 03:50:29.43	
	12/10/2009 03:50	ITL Completed	2009-10-12 03:30:00.683	2009-10-12 03:50:25.607	
	13/10/2009 03:50	ITL Completed	2009-10-13 03:30:06.09	2009-10-13 03:50:30.427	
	14/10/2009 03:50	ITL Completed	2009-10-14 03:30:02.29	2009-10-14 03:50:29.557	
	15/10/2009 03:50	ITL Completed	2009-10-15 03:30:00.39	2009-10-15 03:50:25.623	
	16/10/2009 03:50	ITL Completed	2009-10-16 03:30:01.123	2009-10-16 03:50:27.53	
	17/10/2009 03:50	ITL Completed	2009-10-17 03:30:01.197	2009-10-17 03:50:51.067	
	18/10/2009 03:50	ITL Completed	2009-10-18 03:30:00.253	2009-10-18 03:50:47.093	
	19/10/2009 03:50	ITL Completed	2009-10-19 03:30:00.207	2009-10-19 03:50:27.22	
	19/10/2009 20:58	ITL Completed	2009-10-19 20:38:51.99	2009-10-19 20:59:36.503	
	20/10/2009 03:50	ITL Completed	2009-10-20 03:30:04.29	2009-10-20 03:50:23.337	
	21/10/2009 06:45	ITL Completed	2009-10-21 06:25:20.657	2009-10-21 06:45:47.757	
	22/10/2009 03:50	ITL Completed	2009-10-22 03:30:00.827	2009-10-22 03:50:26.07	
	23/10/2009 03:50	ITL Completed	2009-10-23 03:30:00.55	2009-10-23 03:50:26.277	
	24/10/2009 03:50	ITL Completed	2009-10-24 03:30:00.48	2009-10-24 03:50:53.503	
	24/10/2009 19:22	ITL Completed	2009-10-24 19:02:31.577	2009-10-24 19:23:28.52	
	25/10/2009 02:50	ITL Completed	2009-10-25 02:30:05.257	2009-10-25 02:50:49.937	
DE10023943	28/10/2009 02:50	ITL Completed with Manual Intervention	2009-10-28 02:30:04.98	2009-10-28 12:24:38.12	INC000000367483 Problem Time sync Summertime
	28/10/2009 12:44	ITL Completed	2009-10-28 12:24:51.307	2009-10-28 12:45:21.823	
	29/10/2009 02:50	ITL Completed	2009-10-29 02:30:00.537	2009-10-29 02:50:46.707	
	30/10/2009 02:50	ITL Completed	2009-10-30 02:30:04.623	2009-10-30 02:50:31.077	
	31/10/2009 02:50	ITL Completed	2009-10-31 02:29:59.073	2009-10-31 02:50:56.15	
	01/11/2009 02:50	ITL Completed	2009-11-01 02:29:58.763	2009-11-01 02:50:57.473	
	02/11/2009 02:50	ITL Completed	2009-11-02 02:30:00.213	2009-11-02 02:50:30.717	
	03/11/2009 02:50	ITL Completed	2009-11-03 02:30:04.547	2009-11-03 02:50:28.663	
DE10024312	04/11/2009 02:50	ITL Completed with Manual Intervention	2009-11-04 02:30:00.297	2009-11-05 11:57:42.77	INC000000393721/ INC000000393473 Problem with DK-511281 and DE-82766
	05/11/2009 12:17	ITL Completed	2009-11-05 11:57:55.677	2009-11-05 12:18:28.287	
	06/11/2009 02:50	ITL Completed	2009-11-06 02:30:01.083	2009-11-06 02:50:35.617	
	07/11/2009 02:50	ITL Completed	2009-11-07 02:30:04.517	2009-11-07 02:50:30.173	
	07/11/2009 15:00	ITL Completed	2009-11-07 14:40:00.5	2009-11-07 15:00:35.797	
	08/11/2009 02:50	ITL Completed	2009-11-08 02:30:05.4	2009-11-08 02:50:35.697	
	09/11/2009 02:50	ITL Completed	2009-11-09 02:30:04.303	2009-11-09 02:51:10.537	
	10/11/2009 02:50	ITL Completed	2009-11-10 02:29:59.897	2009-11-10 02:50:33.987	
	11/11/2009 02:50	ITL Completed	2009-11-11 02:30:04.21	2009-11-11 02:50:26.913	
	12/11/2009 02:50	ITL Completed	2009-11-12 02:29:59.68	2009-11-12 02:50:32.147	
	13/11/2009 02:50	ITL Completed	2009-11-13 02:30:04.547	2009-11-13 02:50:32.5	
	14/11/2009 02:50	ITL Completed	2009-11-14 02:30:00.967	2009-11-14 02:51:02.957	
	15/11/2009 02:50	ITL Completed	2009-11-15 02:30:00.667	2009-11-15 02:51:02.09	
	16/11/2009 02:50	ITL Completed	2009-11-16 02:30:04.383	2009-11-16 02:50:29.99	

Transaction	Snapshot date & Time	Reconciliation Status	Action Begin Date & Time	Action End Date & Time	Remarks
	17/11/2009 02:50	ITL Completed	2009-11-17 02:30:00.697	2009-11-17 02:50:30.027	
	18/11/2009 02:50	ITL Completed	2009-11-18 02:30:00.233	2009-11-18 02:50:31.357	
	19/11/2009 02:50	ITL Completed	2009-11-19 02:30:04.94	2009-11-19 02:50:29.55	
	20/11/2009 02:50	ITL Completed	2009-11-20 02:30:01.3	2009-11-20 02:50:31.42	
	21/11/2009 02:50	ITL Completed	2009-11-21 02:30:00.553	2009-11-21 02:51:05.743	
	22/11/2009 02:50	ITL Completed	2009-11-22 02:30:00.08	2009-11-22 02:50:35.127	
	23/11/2009 02:50	ITL Completed	2009-11-23 02:30:00.027	2009-11-23 02:50:34.227	
	24/11/2009 02:50	ITL Completed	2009-11-24 02:30:00.633	2009-11-24 02:50:31.91	
	25/11/2009 02:50	ITL Completed	2009-11-25 02:30:00.41	2009-11-25 02:50:32.7	
	26/11/2009 02:50	ITL Completed	2009-11-26 02:30:00.117	2009-11-26 02:50:31.42	
	27/11/2009 02:50	ITL Completed	2009-11-27 02:30:00.787	2009-11-27 02:50:35.743	
	28/11/2009 02:50	ITL Completed	2009-11-28 02:30:00.593	2009-11-28 02:50:53.657	
	29/11/2009 02:50	ITL Completed	2009-11-29 02:29:59.393	2009-11-29 02:51:13.367	
	30/11/2009 02:50	ITL Completed	2009-11-30 02:30:00.157	2009-11-30 02:50:30.337	
	01/12/2009 02:50	ITL Completed	2009-12-01 02:30:04.31	2009-12-01 02:50:31.763	
	02/12/2009 02:50	ITL Completed	2009-12-02 02:30:04.527	2009-12-02 02:50:35.073	
	03/12/2009 02:50	ITL Completed	2009-12-03 02:30:00.923	2009-12-03 02:50:34.813	
	04/12/2009 02:50	ITL Completed	2009-12-04 02:30:00.493	2009-12-04 02:50:32.273	
	05/12/2009 02:50	ITL Completed	2009-12-05 02:29:59.477	2009-12-05 02:51:04.357	
	06/12/2009 02:50	ITL Completed	2009-12-06 02:29:59.6	2009-12-06 02:50:56.7	
	07/12/2009 02:50	ITL Completed	2009-12-07 02:30:03.99	2009-12-07 02:50:36.163	
	08/12/2009 02:50	ITL Completed	2009-12-08 02:30:04.773	2009-12-08 02:50:36.577	
	09/12/2009 02:50	ITL Completed	2009-12-09 02:30:03.597	2009-12-09 02:50:28.047	
	10/12/2009 02:50	ITL Completed	2009-12-10 02:30:00.07	2009-12-10 02:50:36.1	
	11/12/2009 02:50	ITL Completed	2009-12-11 02:30:00.767	2009-12-11 02:50:42.62	
	12/12/2009 02:50	ITL Completed	2009-12-12 02:30:00.577	2009-12-12 02:51:07.03	
	13/12/2009 02:50	ITL Completed	2009-12-13 02:30:04.67	2009-12-13 02:51:07.107	
	14/12/2009 02:50	ITL Completed	2009-12-14 02:29:59.987	2009-12-14 02:50:33.16	
	15/12/2009 02:50	ITL Completed	2009-12-15 02:30:04.777	2009-12-15 02:50:41.973	
DE10026248	15/12/2009 13:34	ITL Completed with Manual Intervention	2009-12-15 13:14:52.617	2009-12-15 14:36:39.193	INC000000475441/ INC000000507059 Reversal of Voluntary Cancellation - DE-82818
DE10026300	15/12/2009 14:58	ITL Completed with Manual Intervention	2009-12-15 14:38:48.203	2009-12-16 11:03:24.2	INC000000475441 Reversal of Voluntary Cancellation - DE-82818
DE10026601	16/12/2009 11:23	ITL Completed with Manual Intervention	2009-12-16 11:03:22.06	2009-12-16 11:08:50.987	INC000000475441/ INC000000507059 / INC000000507765 Reversal of Voluntary Cancellation - DE-82818
	17/12/2009 02:50	ITL Completed	2009-12-17 02:30:00.737	2009-12-17 02:50:35.407	
	17/12/2009 08:41	ITL Completed	2009-12-17 08:21:46.197	2009-12-17 08:42:17.627	
	17/12/2009 16:15	ITL Completed	2009-12-17 15:55:04.183	2009-12-17 16:15:39.29	
	18/12/2009 02:50	ITL Completed	2009-12-18 02:30:01.04	2009-12-18 02:50:29.227	
	19/12/2009 02:50	ITL Completed	2009-12-19 02:30:00.667	2009-12-19 02:51:06.873	
	20/12/2009 02:50	ITL Completed	2009-12-20 02:30:04.983	2009-12-20 02:51:02.487	
	21/12/2009 02:50	ITL Completed	2009-12-21 02:30:00.727	2009-12-21 02:50:29.813	
	22/12/2009 02:50	ITL Completed	2009-12-22 02:29:58.197	2009-12-22 02:50:33.203	
	23/12/2009 02:50	ITL Completed	2009-12-23 02:30:00.25	2009-12-23 02:50:35.507	
	24/12/2009 02:50	ITL Completed	2009-12-24 02:30:00.267	2009-12-24 02:50:35.313	
	25/12/2009 02:50	ITL Completed	2009-12-25 02:30:00.127	2009-12-25 02:50:35.39	
	26/12/2009 02:50	ITL Completed	2009-12-26 02:30:00.42	2009-12-26 02:51:06.713	
	27/12/2009 02:50	ITL Completed	2009-12-27 02:30:04.727	2009-12-27 02:50:59.13	
	28/12/2009 02:50	ITL Completed	2009-12-28 02:30:00.89	2009-12-28 02:50:35.903	
	29/12/2009 02:50	ITL Completed	2009-12-29 02:30:00.3	2009-12-29 02:50:40.237	
	30/12/2009 02:50	ITL Completed	2009-12-30 02:29:59.737	2009-12-30 02:50:34.657	
	31/12/2009 02:50	ITL Completed	2009-12-31 02:30:04.953	2009-12-31 02:50:34.78	

22.2.4.3 SCREENSHOTS OF PUBLICLY AVAILABLE INFORMATION

Mozilla Firefox

Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe

https://www.register.dehst.de/crweb/report/public/publicReportList.do

https://www.register.dehst.de/crweb/report/public/publicReportList.do

Umwelt Bundes Amt DEHST
Für Mensch und Umwelt Deutsches Umweltministerium

Public Site [DE] [EN]

Welcome

Reporting

Public reports

Request Account

Person Holding Account

Operator Holding Account

Help

Public reports

Operator Holding Accounts	Information about operator holding accounts included in EU Emission trading Scheme, operators, representatives, contacts, installations, verified emissions and compliance status
Accounts	Information about account name, account type, account holder, account representatives and person identifier of all accounts
Authorised Persons	According to Kyoto Protocol, Decision 13/CMP.1, annex, paragraph 48 persons authorised by Germany to hold 1-0 AAU, 2-0 RMU, 3-0 ERU, 4-0 ERU und 5-0 CER
Verifier	List of authorised verifiers in the EU Emission trading Scheme by Germany
Balances and Transactions	Balances and transactions information
Joint Implementation Projects	German JI projects and issued ERUs
Commitment Period Reserve (CPR)	Information about the commitment period reserve (according decision 11/CMP.1 UNFCCC)

On this page non-confidential information about accounts, legal entities, representatives and transactions of the German Emissions Trading Registry is published according to:

- Kyoto Protocol, decision 13/CMP.1, annex, paragraph 44-48 of the UNFCCC
- EU Registry Regulation No 2216/2004, annex XVI and Regulation No 916/2007

© Copyright by European Commission and Umweltbundesamt. All rights reserved. | Mon Apr 12 15:41:54 CEST 2010 | emissionsregister@dehst.de

Partig

<https://www.register.dehst.de/crweb/report/public/publicReportList.do>

Umwelt Bundes Amt DEHST

Public Site

Welcome

Reporting

Public reports

Request Account

Person Holding Account

Operator Holding Account

Help

Issuance of Kyoto Units

The table below shows the total quantity of 1-0 AAU issued on the basis of the assigned amount pursuant to Article 3, paragraphs 7 and 8, 3-0 ERU and 4-0 ERU issued on the basis of Article 6 projects and 2-0 RMU issued on the basis of each activity under Article 3, paragraphs 3 and 4

Year	1-0 AAU	2-0 RMU	3-0 ERU	4-0 ERU
2008	4,868,096,694	0	0	0
2009	0	0	143,492	0

In cooperation with the European Commission

© Copyright by European Commission and Umwelt Bundesamt. All rights reserved. | 16th Apr 12 10:45:22 CEST 2010 | Internal | E-Mail: environment@dehst.de

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_1

Mozilla Firefox

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_3

Umwelt Bundes Amt DEHST
Für Mensch und Umwelt Deutsche Bundesumweltbehörde

Public Site | DE | EN

Welcome

Reporting

Public reports

Request Account

Person Holding Account

Operator Holding Account

Help

In cooperation with the European Commission

Cancellations

Net source cancellation

The table below shows the total quantity of Kyoto units cancelled on the basis of activities under Article 3, paragraphs 3 and 4 of the Kyoto protocol.

Year	1-8 AAU	2-8 RMU	3-8 ERU	4-8 ERU	5-8 CER
2008	0	0	0	0	0
2009	0	0	0	0	0

Non-compliance cancellation

The table below shows the total quantity of Kyoto units cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1 of the Kyoto protocol.

Year	1-8 AAU	2-8 RMU	3-8 ERU	4-8 ERU	5-8 CER
2008	0	0	0	0	0
2009	0	0	0	0	0

Voluntary cancellation

The table below shows the total quantity of Kyoto units and EU-allowances (EUA) voluntary cancelled with transaction types 04-00 and 10-01.

Year	1-8 AAU	9-2 EUA	1-1 EUA	2-8 RMU	3-8 ERU	4-8 ERU	5-8 CER	6-8 ICER	7-8 ICER
2005	0	2	0	0	0	0	0	0	0
2006	0	134	0	0	0	0	0	0	0
2007	0	108,991	0	0	0	0	0	0	0
2008	0	0	215	0	0	0	100,425	0	0
2009	0	0	1,208	0	66	0	193,981	0	0

Fertig

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_3

Part 1

Mozilla Firefox

File Edit View History Bookmarks Tools Help

Univ.-Bund.de (DE) https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_3

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_3

Excess issuance cancellation

The table below shows the total quantity of Kyoto units cancelled regarding excess issuance for CDM projects.

Year	1-B AAU	2-B RMU	3-B ERU	4-B ERU	5-B CER
2008	0	0	0	0	0
2009	0	0	0	0	0

Cancellation of invalid Kyoto units

The table below shows the total quantity of other Kyoto units cancelled.

Year	1-B AAU	2-B RMU	3-B ERU	4-B ERU	5-B CER	6-B ICER	7-B ICER
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0

Cancellation and Replacement

The table below shows the total quantity of allowances (EUA) from the previous commitment period cancelled and replaced.

Commitment Period	8-2 EUA Cancelled	8-2 EUA Replaced	1-1 EUA Cancelled	1-1 EUA Replaced
2005-2007	82,522,724	0	0	0

© Copyright by European Commission and Umweltbundesamt. All rights reserved. | Mon Apr 12 10:46:58 CEST 2010 | [E-Mail: emissionshandel@umwelt.de](mailto:emissionshandel@umwelt.de)

Fertig

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_3

Part 2

Mozilla Firefox

Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_4

Umwelt Bundes Amt DEHSt
Für Mensch und Umwelt Deutsche Umwelthochschule

Public Site | DE | EN

Welcome

Reporting

Public reports

Request Account

Person Holding Account

Operator Holding Account

Help

 In cooperation with the
European Commission

Public Site

Retirement and carry over

Retirement

The table below shows the total quantity of retired Kyoto units and EU-Allowances with transaction type 04-03 und 05-00.

Year	1-0 AAU	0-2 EUA	1-1 EUA	2-0 RNU	3-0 ERU	4-0 ERU	5-0 CER	6-0 ICER	7-0 ICER
2005	0	0	0	0	0	0	0	0	0
2006	0	473,967,578	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0
2008	0	973,183,620	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0

Carry over

The table below shows the total quantity of retired Kyoto units carried over from the previous commitment period (CP).

Commitment Period	1-0 AAU	3-0 ERU	4-0 ERU	5-0 CER
Carried over from CP 2006-2012 to CP 2013-2017	0	0	0	0

Perfing

https://www.register.dehst.de/crweb/report/public/details7.do?event=details7_4

Mozilla Firefox

Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe

https://www.register.dehst.de/crweb/report/public/authorisedPeople.do

https://www.register.dehst.de

Umwelt Bundes Amt DEHST
für Mensch und Umwelt Deutsche Bundesagentur für Umwelt

Public Site [de] [en]

Welcome

Reporting

Public reports

Request Account

Person Holding Account

Operator Holding Account

Help

Authorised persons

According to national Project Mechanism Law (ProMechG, Projekt-Mechanismen-Gesetz) in Germany each account holder of a Person and Operator Holding Account is authorised to hold 3-0 ERU, 4-0 ERU, 5-0 CER and 1-0 AAU converted in 1-1 EUA. These account holders and persons are shown at the site → **Accounts** of the public area, as long as the display of personal information isn't marked as confidential.

The table below shows people authorised by Germany to hold 1-0 AAU, 2-0 RMU, 6-0 ICER and 7-0 ICER.

Name	1-0 AAU	2-0 RMU	6-0 ICER	7-0 ICER
No entries				

→ **Back**

In cooperation with the **European Commission**

© Copyright by European Commission and Umweltbundesamt. All rights reserved. | Web Apr 12 11:05:40 CEST 2010 | [reprint](#) | E-Mail: entwässerung@umwelt.de

Partig

<https://www.register.dehst.de/crweb/report/public/authorisedPeople.do>

Mozilla Firefox

Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe

umweltbundesamt.de https://www.register.dehst.de/crweb/report/public/account.do

https://www.register.dehst.de/crweb/report/public/account.do

Umwelt Bundes Amt **DEHST**
für Wasser und Umwelt Deutsche Umweltanwaltschaft

Public Site

Welcome

Reporting

Public reports

Request Account

Person Holding Account

Operator Holding Account

Help

Information about all accounts, account holders and representatives

Account holder: Account identifier:

Account name: Account type:

Primary authorized representative: Secondary authorized representative:

Additional authorized representative: Permit identifier:

Account Status:

Search Reset

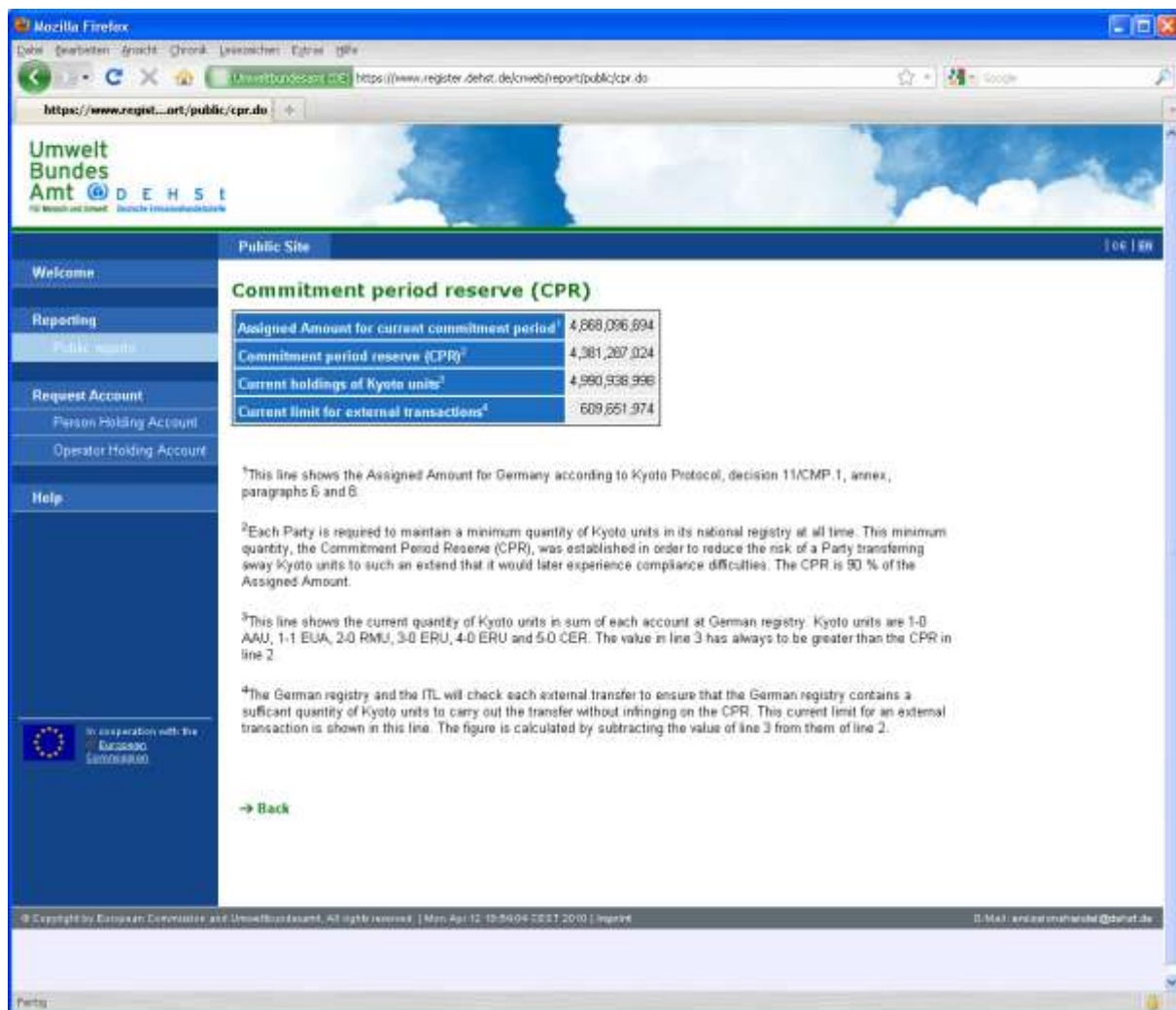
<< < page 1 of 247 pages To page >>

The document is being generated based on the (filtered) table data.

Account identifier	Account name	Account type	Account holder	Primary authorized representative	Secondary authorized representative	Additional authorized representative	Permit identifier	Account Status	Details
DE-120-1614-0	1614 - Anlagenkonto	Operator Holding Account	24/7 Netze GmbH	vertraulich	vertraulich		DE-14310-1063	Open	People Unit types
DE-120-1613-0	1613 - Anlagenkonto	Operator Holding Account	24/7 Netze GmbH	vertraulich	vertraulich		DE-14310-1062	Open	People Unit types
DE-121-2103-0	2103 - 24/7 Trading GmbH Personenkonto	Person Holding Account	24/7 Trading GmbH	Pomplun, Ulrich	Benke, Viktor	Nieberle, Michael		Open	People Unit types
DE-121-1923-0	1923 - 24staben GmbH Personenkonto	Person Holding Account	24staben GmbH	Bierwing, Jörg	Bonds, Björn			Open	People Unit types
DE-120-449-0	449 - Anlagenkonto	Operator Holding Account	A. Berentz & Co. Klinker- u. Keramik-Werk	Berentz, Rainer	vertraulich		DE-14260-0171	Open	People Unit types
DE-120-447-0	447 - Anlagenkonto	Operator Holding Account	A. Berentz & Co. Klinker- u. Keramik-Werk	Berentz, Rainer	vertraulich		DE-14260-0170	Open	People Unit types
DE-120-932-0	932 - Anlagenkonto	Operator Holding Account	A. Nattermann & Co. GmbH	Stüfgen, Oliver	Buchmeier, Walter		DE-14310-0326	Closed	People Unit types
DE-120-596-0	596 - Anlagenkonto	Operator Holding Account	A. Oberauf GmbH	vertraulich	vertraulich		DE-14200-0090	Open	People Unit types

Partig

<https://www.register.dehst.de/crweb/report/public/account.do>



<https://www.register.dehst.de/crweb/report/public/cpr.do>

22.2.4.4 List of publicly available information for each account

Account identifier

Account name

Account type

Account holder

Primary authorized representative

- Role
- Name
- Person Identifier
- Additional address
- Address
- Postal Code and City
- Country
- Tel
- Tel 2
- Fax
- Email

Secondary authorized representative

- Contact information please see Primary authorized representative

Additional authorized representative

- Contact information please see Primary authorized representative

Permit identifier**Allowances (tradable unit types for this account)****Publicly available information for each JI project**

- Project name
- Project location
- Years of ERU issuance
- Downloadable reports

Publicly available holding information

- The total quantity of AAU issued on the basis of the assigned amount pursuant to Article 3, paragraphs 7 and 8
- The total quantity of ERU issued on the basis of Article 6 projects
- The total quantity of ERU, CER, AAU and RMU acquired from other registries and the identity of the transferring accounts and registries
- The total quantity of RMU issued on the basis of each activity under Article 3, paragraphs 3 and 4
- The total quantity of ERU, CER, AAU and RMU transferred to other registries and the identity of the acquiring accounts and registries
- The total quantity of ERU, CER, AAU and RMU cancelled on the basis of activities under Article 3, paragraphs 3 and 4
- The total quantity of ERU, CER, AAU and RMU cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1
- The total quantity of other ERU, CER, AAU and RMU cancelled
- The total quantity of ERUs, CERs, AAUs and RMUs retired
- The total quantity of ERUs, CERs, and AAUs carried over from the previous commitment period

22.3 Additional information about trends for greenhouse gases

This section presents the detailed tables relative to the trend discussion in Chapters □ and 0.

Table 318: Emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks, in CO ₂ equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Net CO ₂ emissions / storage	1.010.787	973.163	925.675	916.621	900.385	898.840	919.567	890.637	882.712	855.487	858.973	874.554	907.982	906.523	897.673	880.091	884.793	862.710	863.541	807.268
CO ₂ emissions (not including LULUCF)	1.041.688	1.004.309	957.117	948.237	932.049	930.420	951.353	922.536	914.621	887.507	890.994	907.051	890.934	889.848	881.167	863.955	870.164	847.276	847.967	788.803
CH ₄	107.293	102.596	98.915	98.749	94.708	92.198	89.821	85.249	80.191	78.374	74.759	71.745	68.474	64.888	59.796	57.225	54.172	52.048	51.262	48.799
N ₂ O	87.831	84.492	84.772	82.595	82.322	82.614	84.603	81.710	68.460	64.879	64.992	65.952	64.875	63.669	67.290	64.922	63.801	66.308	67.360	66.894
HFCs	4.369	4.013	4.189	6.159	6.330	6.469	5.855	6.392	6.961	7.204	6.483	7.891	8.794	8.623	9.233	10.001	10.539	11.145	11.474	11.952
PFCs	2.708	2.333	2.102	1.961	1.650	1.750	1.714	1.368	1.471	1.240	781	717	789	851	822	709	571	530	531	432
SF ₆	4.785	5.118	5.634	6.405	6.993	7.220	6.932	6.905	6.705	5.070	4.826	4.346	3.570	3.490	3.658	3.726	3.651	3.537	3.288	3.223

Total emissions / storage, including LULUCF	1.217.772	1.171.715	1.121.287	1.112.490	1.092.387	1.089.091	1.108.491	1.072.261	1.046.501	1.012.254	1.010.814	1.025.205	1.054.485	1.048.043	1.038.472	1.016.673	1.017.528	996.276	997.455	938.568
Total emissions, not including CO ₂ from LULUCF	1.248.673	1.202.861	1.152.730	1.144.106	1.124.051	1.120.670	1.140.277	1.104.160	1.078.409	1.044.274	1.042.835	1.057.702	1.037.437	1.031.368	1.021.966	1.000.537	1.002.898	980.843	981.881	920.103

GG emissions / sinks, by source and sink categories, in CO ₂ equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	1.019.041	983.909	934.694	926.967	905.413	903.117	925.344	893.686	884.476	859.991	857.747	878.128	863.475	855.429	842.054	826.035	830.703	807.504	809.591	760.126
2. Industrial processes	94.532	90.578	92.554	92.704	98.906	97.013	95.748	95.470	81.403	74.316	77.143	74.409	72.856	78.275	83.385	80.685	81.938	84.623	82.017	73.324
3. Solvent and other product use	4.477	4.337	4.157	4.074	3.547	3.553	3.471	3.446	3.420	3.165	2.909	2.687	2.484	2.267	2.195	2.052	2.074	1.949	1.812	1.786
4. Agriculture	86.740	79.648	77.077	76.948	74.128	76.403	77.114	76.386	76.456	77.242	77.191	76.410	74.073	72.522	74.095	73.402	71.778	71.466	74.508	72.702
5. Land use, land-use changes & forestry	-30.129	-30.379	-30.647	-30.845	-30.895	-30.815	-31.016	-31.135	-31.145	-31.257	-31.257	-31.736	17.809	17.445	17.268	16.897	15.270	16.404	16.344	18.869
CO ₂	-30.901	-31.146	-31.442	-31.616	-31.664	-31.579	-31.786	-31.899	-31.909	-32.020	-32.022	-32.497	17.048	16.675	16.506	16.136	14.629	15.434	15.575	18.464
N ₂ O & CH ₄	772	767	795	771	769	765	770	765	763	763	765	761	761	770	762	762	641	970	769	405
6. Waste	43.111	43.622	43.453	42.642	41.288	39.820	37.830	34.407	31.892	28.797	27.081	25.307	23.787	22.106	19.475	17.602	15.764	14.331	13.182	11.760

Table 319: Contributions to emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks; shares for various GG, not including CO ₂ from LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO ₂ emissions (not including LULUCF)	83,4	83,5	83,0	82,9	82,9	83,0	83,4	83,6	84,8	85,0	85,4	85,8	85,9	86,3	86,2	86,3	86,8	86,4	86,4	85,7
CH ₄	8,6	8,5	8,6	8,6	8,4	8,2	7,9	7,7	7,4	7,5	7,2	6,8	6,6	6,3	5,9	5,7	5,4	5,3	5,2	5,3
N ₂ O	7,0	7,0	7,4	7,2	7,3	7,4	7,4	7,4	6,3	6,2	6,2	6,2	6,3	6,2	6,6	6,5	6,4	6,8	6,9	7,3
HFCs	0,3	0,3	0,4	0,5	0,6	0,6	0,5	0,6	0,6	0,7	0,6	0,7	0,8	0,8	0,9	1,0	1,1	1,1	1,2	1,3
PFCs	0,2	0,2	0,2	0,2	0,1	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,0
SF ₆	0,4	0,4	0,5	0,6	0,6	0,6	0,6	0,6	0,6	0,5	0,5	0,4	0,3	0,3	0,4	0,4	0,4	0,4	0,3	0,4
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

GG emissions / sinks; shares for emission & sink categories, not including CO ₂ from LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	81,6	81,8	81,1	81,0	80,5	80,6	81,2	80,9	82,0	82,4	82,3	83,0	83,2	82,9	82,4	82,6	82,8	82,3	82,5	82,6
2. Industrial processes	7,6	7,5	8,0	8,1	8,8	8,7	8,4	8,6	7,5	7,1	7,4	7,0	7,0	7,6	8,2	8,1	8,2	8,6	8,4	8,0
3. Solvent and other product use	0,4	0,4	0,4	0,4	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
4. Agriculture	6,9	6,6	6,7	6,7	6,6	6,8	6,8	6,9	7,1	7,4	7,4	7,2	7,1	7,0	7,3	7,3	7,2	7,3	7,6	7,9
5. Land use, land-use changes & forestry (N ₂ O)	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,0
6. Waste	3,5	3,6	3,8	3,7	3,7	3,6	3,3	3,1	3,0	2,8	2,6	2,4	2,3	2,1	1,9	1,8	1,6	1,5	1,3	1,3
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Table 320: Emissions of direct and indirect greenhouse gases and SO₂ in Germany since 1990

Emissions change (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Net CO ₂ emissions / storage	1.010.787	973.163	925.675	916.621	900.385	898.840	919.567	890.637	882.712	855.487	858.973	874.554	907.982	906.523	897.673	880.091	884.793	862.710	863.541	807.268
CO ₂ emissions (not including LULUCF)	1.041.688	1.004.309	957.117	948.237	932.049	930.420	951.353	922.536	914.621	887.507	890.994	907.051	890.934	889.848	881.167	863.955	870.164	847.276	847.967	788.803
CH ₄	5.109	4.886	4.710	4.702	4.510	4.390	4.277	4.059	3.819	3.732	3.560	3.416	3.261	3.090	2.847	2.725	2.580	2.478	2.441	2.324
N ₂ O	283	273	273	266	266	266	273	264	221	209	210	213	209	205	217	209	206	214	217	216
HFCs (CO ₂ equivalent)	4.369	4.013	4.189	6.159	6.330	6.469	5.855	6.392	6.961	7.204	6.483	7.891	8.794	8.623	9.233	10.001	10.539	11.145	11.474	11.952
PFCs (CO ₂ equivalent)	2.708	2.333	2.102	1.961	1.650	1.750	1.714	1.368	1.471	1.240	781	717	789	851	822	709	571	530	531	432
SF ₆ (CO ₂ equivalent)	4.785	5.118	5.634	6.405	6.993	7.220	6.932	6.905	6.705	5.070	4.826	4.346	3.570	3.490	3.658	3.726	3.651	3.537	3.288	3.223
CO	12.259	10.084	8.718	7.900	6.947	6.560	6.127	6.000	5.564	5.189	4.894	4.640	4.345	4.160	3.933	3.717	3.649	3.554	3.488	3.086
NMVOC	3.750	3.219	2.963	2.766	2.269	2.156	2.072	2.028	1.981	1.821	1.662	1.569	1.500	1.430	1.436	1.413	1.402	1.347	1.296	1.284
NO _x	2.942	2.717	2.551	2.443	2.295	2.209	2.128	2.047	2.001	1.973	1.911	1.830	1.737	1.676	1.643	1.581	1.584	1.521	1.465	1.367
SO ₂	5.312	3.929	3.205	2.860	2.394	1.725	1.460	1.221	983	810	656	650	601	586	571	539	543	517	507	448

Table 321: Changes in emissions of direct and indirect greenhouse gases and SO₂ in Germany since 1990

Change in emissions with respect to the base year, i.e. 1990 (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Net CO ₂ emissions / storage	0,0	-3,7	-8,4	-9,3	-10,9	-11,1	-9,0	-11,9	-12,7	-15,4	-15,0	-13,5	-10,2	-10,3	-11,2	-12,9	-12,5	-14,6	-14,6	-20,1
CO ₂ emissions (not including LULUCF)	0,0	-3,6	-8,1	-9,0	-10,5	-10,7	-8,7	-11,4	-12,2	-14,8	-14,5	-12,9	-14,5	-14,6	-15,4	-17,1	-16,5	-18,7	-18,6	-24,3
CH ₄	0,0	-4,4	-7,8	-8,0	-11,7	-14,1	-16,3	-20,5	-25,3	-27,0	-30,3	-33,1	-36,2	-39,5	-44,3	-46,7	-49,5	-51,5	-52,2	-54,5
N ₂ O	0,0	-3,8	-3,5	-6,0	-6,3	-5,9	-3,7	-7,0	-22,1	-26,1	-26,0	-24,9	-26,1	-27,5	-23,4	-26,1	-27,4	-24,5	-23,3	-23,8
HFCs (CO ₂ equivalent)						0,0	-9,5	-1,2	+7,6	+11,4	+0,2	+22,0	+36,0	+33,3	+42,7	+54,6	+62,9	+72,3	+77,4	+84,8
PFCs (CO ₂ equivalent)						0,0	-2,1	-21,8	-15,9	-29,1	-55,3	-59,0	-54,9	-51,4	-53,0	-59,5	-67,4	-69,7	-69,6	-75,3
SF ₆ (CO ₂ equivalent)						0,0	-4,0	-4,4	-7,1	-29,8	-33,2	-39,8	-50,6	-51,7	-49,3	-48,4	-49,4	-51,0	-54,5	-55,4
Development of GG overall																				
Total emissions with respect to EU burden-sharing ¹⁰²	+1,3	-2,4	-6,5	-7,2	-8,8	-9,1	-7,5	-10,4	-12,5	-15,3	-15,4	-14,2	-15,8	-16,3	-17,1	-18,8	-18,6	-20,4	-20,3	-25,3
CO	0,0	-17,7	-28,9	-35,6	-43,3	-46,5	-50,0	-51,1	-54,6	-57,7	-60,1	-62,2	-64,6	-66,1	-67,9	-69,7	-70,2	-71,0	-71,5	-74,8
NMVOC	0,0	-14,1	-21,0	-26,2	-39,5	-42,5	-44,7	-45,9	-47,2	-51,4	-55,7	-58,1	-60,0	-61,9	-61,7	-62,3	-62,6	-64,1	-65,4	-65,8
NO _x	0,0	-7,6	-13,3	-17,0	-22,0	-24,9	-27,7	-30,4	-32,0	-33,0	-35,1	-37,8	-41,0	-43,0	-44,2	-46,3	-46,2	-48,3	-50,2	-53,5
SO ₂	0,0	-26,0	-39,7	-46,2	-54,9	-67,5	-72,5	-77,0	-81,5	-84,8	-87,6	-87,8	-88,7	-89,0	-89,3	-89,9	-89,8	-90,3	-90,5	-91,6

¹⁰² Defined base-year emissions of 1,232,430 Gg CO₂ equivalent; cf. Chapter □

Table 322: Changes in emissions of direct and indirect greenhouse gases and SO₂ in Germany, in each case since the relevant previous year

Emissions change with respect to the previous year (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Net CO₂ emissions / storage</i>	0,0	-3,7	-4,9	-1,0	-1,8	-0,2	+2,3	-3,1	-0,9	-3,1	+0,4	+1,8	+3,8	-0,2	-1,0	-2,0	+0,5	-2,5	+0,1	-6,5
CO ₂ emissions (not including LULUCF)	0,0	-3,6	-4,7	-0,9	-1,7	-0,2	+2,2	-3,0	-0,9	-3,0	+0,4	+1,8	-1,8	-0,1	-1,0	-2,0	+0,7	-2,6	+0,1	-7,0
CH ₄	0,0	-4,4	-3,6	-0,2	-4,1	-2,7	-2,6	-5,1	-5,9	-2,3	-4,6	-4,0	-4,6	-5,2	-7,8	-4,3	-5,3	-3,9	-1,5	-4,8
N ₂ O	0,0	-3,8	+0,3	-2,6	-0,3	+0,4	+2,4	-3,4	-16,2	-5,2	+0,2	+1,5	-1,6	-1,9	+5,7	-3,5	-1,7	+3,9	+1,6	-0,7
HFCs (CO ₂ equivalent)	0,0	-8,1	+4,4	+47,0	+2,8	+2,2	-9,5	+9,2	+8,9	+3,5	-10,0	+21,7	+11,4	-2,0	+7,1	+8,3	+5,4	+5,7	+2,9	+4,2
PFCs (CO ₂ equivalent)	0,0	-13,8	-9,9	-6,7	-15,9	+6,1	-2,1	-20,2	+7,5	-15,7	-37,0	-8,2	+10,0	+7,8	-3,3	-13,8	-19,4	-7,2	+0,3	-18,6
SF ₆ (CO ₂ equivalent)	0,0	+7,0	+10,1	+13,7	+9,2	+3,3	-4,0	-0,4	-2,9	-24,4	-4,8	-10,0	-17,8	-2,3	+4,8	+1,9	-2,0	-3,1	-7,0	-2,0
Changes in total GG emissions and storage																				
<i>Total emissions / storage, including LULUCF</i>	0,0	-3,8	-4,3	-0,8	-1,8	-0,3	+1,8	-3,3	-2,4	-3,3	-0,1	+1,4	+2,9	-0,6	-0,9	-2,1	+0,1	-2,1	+0,1	-5,9
Total emissions, not including CO ₂ from LULUCF	0,0	-3,7	-4,2	-0,7	-1,8	-0,3	+1,7	-3,2	-2,3	-3,2	-0,1	+1,4	-1,9	-0,6	-0,9	-2,1	+0,2	-2,2	+0,1	-6,3
CO	0,0	-17,7	-13,5	-9,4	-12,1	-5,6	-6,6	-2,1	-7,3	-6,7	-5,7	-5,2	-6,3	-4,3	-5,5	-5,5	-1,8	-2,6	-1,9	-11,5
NM VOC	0,0	-14,1	-8,0	-6,7	-18,0	-5,0	-3,9	-2,1	-2,3	-8,1	-8,7	-5,6	-4,4	-4,6	+0,4	-1,6	-0,8	-3,9	-3,8	-1,0
NO _x	0,0	-7,6	-6,1	-4,2	-6,1	-3,8	-3,6	-3,8	-2,2	-1,4	-3,1	-4,3	-5,0	-3,6	-1,9	-3,7	+0,2	-4,0	-3,7	-6,7
SO ₂	0,0	-26,0	-18,4	-10,8	-16,3	-27,9	-15,4	-16,3	-19,5	-17,6	-18,9	-0,9	-7,7	-2,4	-2,6	-5,6	+0,9	-4,8	-2,1	-11,5

Table 323: Changes in emissions in Germany, by source categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990; change in %	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	0,0	-3,4	-8,3	-9,0	-11,2	-11,4	-9,2	-12,3	-13,2	-15,6	-15,8	-13,8	-15,3	-16,1	-17,4	-18,9	-18,5	-20,8	-20,6	-25,4
2. Industrial processes	0,0	-4,2	-2,1	-1,9	4,6	2,6	1,3	1,0	-13,9	-21,4	-18,4	-21,3	-22,9	-17,2	-11,8	-14,6	-13,3	-10,5	-13,2	-22,4
3. Solvent and other product use	0,0	-3,1	-7,1	-9,0	-20,8	-20,6	-22,5	-23,0	-23,6	-29,3	-35,0	-40,0	-44,5	-49,4	-51,0	-54,2	-53,7	-56,5	-59,5	-60,1
4. Agriculture	0,0	-8,2	-11,1	-11,3	-14,5	-11,9	-11,1	-11,9	-11,9	-11,0	-11,0	-11,9	-14,6	-16,4	-14,6	-15,4	-17,2	-17,6	-14,1	-16,2
5. Land use, land-use changes & forestry	0,0	0,8	1,7	2,4	2,5	2,3	2,9	3,3	3,4	3,7	3,7	5,3	-158,7	-157,5	-156,9	-155,7	-150,3	-153,9	-154,0	-162,3
CO ₂ (net sink)	0,0	0,8	1,7	2,3	2,5	2,2	2,9	3,2	3,3	3,6	3,6	5,2	-154,8	-153,6	-153,0	-151,8	-146,9	-149,4	-150,2	-159,4
N ₂ O & CH ₄	0,0	-0,6	3,0	-0,1	-0,5	-1,0	-0,2	-1,0	-1,2	-1,1	-1,0	-1,4	-1,4	-0,3	-1,3	-1,4	-17,1	25,5	-0,4	-47,6
6. Waste	0,0	1,2	0,8	-1,1	-4,2	-7,6	-12,3	-20,2	-26,0	-33,2	-37,2	-41,3	-44,8	-48,7	-54,8	-59,2	-63,4	-66,8	-69,4	-72,7

Emissions change, in each case with respect to the previous year; change in %	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	0,0	-3,4	-5,0	-0,8	-2,3	-0,3	2,5	-3,4	-1,0	-2,8	-0,3	2,4	-1,7	-0,9	-1,6	-1,9	0,6	-2,8	0,3	-6,1
2. Industrial processes	0,0	-4,2	2,2	0,2	6,7	-1,9	-1,3	-0,3	-14,7	-8,7	3,8	-3,5	-2,1	7,4	6,5	-3,2	1,6	3,3	-3,1	-10,6
3. Solvent and other product use	0,0	-3,1	-4,1	-2,0	-12,9	0,2	-2,3	-0,7	-0,7	-7,5	-8,1	-7,7	-7,5	-8,7	-3,2	-6,5	1,1	-6,0	-7,0	-1,5
4. Agriculture	0,0	-8,2	-3,2	-0,2	-3,7	3,1	0,9	-0,9	0,1	1,0	-0,1	-1,0	-3,1	-2,1	2,2	-0,9	-2,2	-0,4	4,3	-2,4
5. Land use, land-use changes & forestry	0,0	0,8	0,9	0,6	0,2	-0,3	0,7	0,4	0,0	0,4	0,0	1,5	-155,7	-2,1	-1,0	-2,2	-9,7	7,2	0,2	15,3
CO ₂ (net sink)	0,0	0,8	0,9	0,6	0,2	-0,3	0,7	0,4	0,0	0,3	0,0	1,5	-152,1	-2,2	-1,0	-2,3	-9,4	5,3	1,5	18,4
N ₂ O & CH ₄	0,0	-0,6	3,6	-3,0	-0,4	-0,5	0,7	-0,7	-0,2	0,0	0,1	-0,4	0,0	1,1	-1,0	-0,1	-15,9	51,4	-20,7	-47,4
6. Waste	0,0	1,2	-0,4	-1,9	-3,2	-3,6	-5,0	-9,0	-7,3	-9,7	-6,0	-6,5	-6,0	-7,1	-11,9	-9,6	-10,4	-9,1	-8,0	-10,8

23 ANNEX 7: TABLE 6.1 OF THE IPCC GOOD PRACTICE GUIDANCE

The uncertainties for the German greenhouse-gas inventories have been determined completely, for all source categories.

Efforts in this area, which began with determination of uncertainties pursuant to Tier 1, are being carried out by data-supplying experts of Federal Environment Agency departments and by external institutions.

Since then, the basis for Tier 2 uncertainties analysis has been created, and the "Crystal Ball" programme for Monte Carlo simulation has been implemented. Tier 2 uncertainties analysis is carried out every three years (it was last carried out for the 2010 report); when it is carried out, it is carried out in addition to Tier 1 uncertainties determination.

At the same time, additional uncertainties have been determined via experts' assessments and added to the CSE database. An uncertainties data set is now available in which most of the uncertainties have been determined via expert estimation. In cases in which experts' assessments are not yet available, a complete data set is obtained by adopting uncertainties from data reported in the relevant technical literature, as well as uncertainties derived via adjustment procedures, using IPCC Conservativeness Factors¹⁰³. The expert assessment process is being continued, systematically and completely. The results of this year's Tier 1 uncertainties analysis are shown, in keeping with the specifications given in Table 6.1 of IPCC Good Practice Guidance, in Table 324.

¹⁰³ FCCC/SBSTA/2003/10/Add.2, Annex III, p. 24-27

Table 324: Table 6.1 of the IPCC Good Practice Guidance - Details

IPCC Source	Fuel Category	Gas	Base year emissions	2009 emissions	Combined Uncertainty as % of total nat. emissions in 2009	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO ₂ equi.]	[Gg CO ₂ equi.]	[%]	[%]	[%]
1 A 1 a	all fuels	Methane	185769.0282	1567841.226	0.102197956	0.540304623	0.111006978
1 A 1 a	all fuels	Carbon dioxide	339017879.1	305235010.1	1.395372066	7.377114085	1.515647107
1 A 1 a	all fuels	Nitrous oxide	3610029.887	3371102.864	0.082064978	0.433864716	0.089138624
1 A 1 b	all fuels	Carbon dioxide	20005878.03	20270164.09	0.125268811	0.66227663	0.136066441
1 A 1 b	all fuels	Methane	13286.2107	7340.273354	0.00023756	0.001255941	0.000258036
1 A 1 b	all fuels	Nitrous oxide	121864.813	62808.73838	0.002267091	0.011985755	0.002462504
1 A 1 c	all fuels	Methane	85304.4171	13799.20193	0.001509108	0.007978417	0.001639186
1 A 1 c	all fuels	Nitrous oxide	684167.613	147748.4877	0.004547762	0.024043307	0.004939759
1 A 1 c	all fuels	Carbon dioxide	64393840.73	13029883.47	0.085331343	0.451133478	0.092686536
1 A 2 a	all fuels	Methane	52068.324	49458.8001	0.001314836	0.006951334	0.001428169
1 A 2 a	all fuels	Nitrous oxide	145518.03	82707.32204	0.003661189	0.019356134	0.003976768
1 A 2 a	all fuels	Carbon dioxide	15581847.2	11564432.97	0.058660213	0.310127381	0.06371647
1 A 2 b	all fuels	Carbon dioxide	1601180.1	1490711.884	0.016927857	0.089494937	0.018386966
1 A 2 b	all fuels	Methane	1164.3765	1374.130934	0.000100082	0.000529116	0.000108708
1 A 2 b	all fuels	Nitrous oxide	17833.99	8018.455956	0.000536578	0.002836804	0.000582829
1 A 2 d	all fuels	Carbon dioxide	3646.958126	14312.7856	8.64778E-05	0.000457194	9.39318E-05
1 A 2 d	all fuels	Methane	549.270225	2267.8425	0.000102195	0.00054029	0.000111004
1 A 2 d	all fuels	Nitrous oxide	2918.97891	12051.963	0.000650853	0.003440959	0.000706954
1 A 2 e	all fuels	Carbon dioxide	1989239	162891.2796	0.001041654	0.005507059	0.00113144
1 A 2 e	all fuels	Methane	3765.405	94.43175976	3.9932E-06	2.11114E-05	4.3374E-06
1 A 2 e	all fuels	Nitrous oxide	25637.775	1846.431493	0.000110841	0.000585999	0.000120395
1 A 2 f	all fuels	Carbon dioxide	156458915.3	88571204.42	0.279619964	1.478307059	0.303721996
1 A 2 f	all fuels	Methane	179080.9592	86969.24974	0.003197297	0.016903608	0.00347289
1 A 2 f	all fuels	Nitrous oxide	1220475.013	649766.6584	0.008647861	0.045719891	0.009393269
1 A 3 a	Aviation Gasoline	Carbon dioxide	2309638.037	2110277.331	0.018359187	0.097062154	0.01994167
1 A 3 a	Aviation Gasoline	Methane	1998.359049	1742.82462	0.000176226	0.000931682	0.000191416
1 A 3 a	Aviation Gasoline	Nitrous oxide	23987.59486	22001.18661	0.002523928	0.013343613	0.00274148
1 A 3 b	all fuels	Carbon dioxide	150358324.9	144615512.3	1.436612454	7.595145569	1.560442238
1 A 3 b	all fuels	Methane	1271099.748	131574.1066	0.003927591	0.020764557	0.004266065
1 A 3 b	all fuels	Nitrous oxide	608351.4068	938874.9413	0.047618625	0.251752232	0.051723145
1 A 3 c	all fuels	Carbon dioxide	2880820.12	1126695.76	0.012543332	0.066314639	0.013624515
1 A 3 c	all fuels	Methane	2309.5212	462.8925316	1.67308E-05	8.84529E-05	1.81729E-05
1 A 3 c	all fuels	Nitrous oxide	12636.22	4942.64	0.000381252	0.002015621	0.000414115
1 A 3 d	Diesel Oil	Carbon dioxide	2065668.2	722857	0.036217197	0.191474659	0.03933897
1 A 3 d	Diesel Oil	Methane	1674.2124	509.981982	3.00714E-05	0.000158983	3.26634E-05
1 A 3 d	Diesel Oil	Nitrous oxide	8590.1	3170.7451	0.0002854	0.001508865	0.00031
1 A 3 e	all fuels	Carbon dioxide	4302257.58	3607559.86	0.170655232	0.902227549	0.185364976
1 A 3 e	all fuels	Methane	6745.606954	3053.143393	0.000107748	0.000569645	0.000117035
1 A 3 e	all fuels	Nitrous oxide	26509.24142	17986.71917	0.001162719	0.006147111	0.00126294

IPCC Source	Fuel Category	Gas	Base year emissions	2009 emissions	Combined Uncertainty as % of total nat. emissions in 2009	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO ₂ equi.]	[Gg CO ₂ equi.]	[%]	[%]	[%]
1 A 4 a	all fuels	Carbon dioxide	63949629.39	37579372.86	0.305224448	1.613673963	0.331533476
1 A 4 a	all fuels	Methane	1216099.165	56466.54579	0.003290082	0.017394148	0.003573673
1 A 4 a	all fuels	Nitrous oxide	144213.4706	100378.4202	0.004756508	0.025146914	0.005166498
1 A 4 b	all fuels	Carbon dioxide	129473971.1	102420894.2	0.904793568	4.783502217	0.982782863
1 A 4 b	all fuels	Methane	1200405.626	572061.3098	0.041642298	0.220156323	0.045231684
1 A 4 b	all fuels	Nitrous oxide	801899.2776	375042.1794	0.011772835	0.06224114	0.012787603
1 A 4 c	all fuels	Carbon dioxide	11059780.98	6051814.294	0.078887344	0.41706506	0.085687092
1 A 4 c	all fuels	Methane	177174.3823	24766.34257	0.001367783	0.007231256	0.00148568
1 A 4 c	all fuels	Nitrous oxide	41727.26978	32897.09993	0.001405644	0.00743142	0.001526804
1 A 5	all fuels	Carbon dioxide	11811085.44	1339130.99	0.006436001	0.034026134	0.006990757
1 A 5	all fuels	Methane	235607.8316	4368.8055	0.000170089	0.000899232	0.00018475
1 A 5	all fuels	Nitrous oxide	70377.15169	9967.91599	0.000639043	0.003378519	0.000694125
1 B 1 a	Solid Fuels	Methane	18415177.65	2763938.852	0.409476566	2.164838623	0.007792915
1 B 1 b	Solid Fuels	Methane	18089.82	6967.359	7.76105E-05	0.000410314	8.43002E-05
1 B 1 c	Solid Fuels	Methane	1806840	75285	0.012048657	0.063699366	0.013087199
1 B 2 a	Liquid Fuels	Carbon dioxide	1183.062534	938.8918088	0.000140544	0.000743036	2.03782E-05
1 B 2 a	Liquid Fuels	Methane	836168.6457	428912.0668	0.002997517	0.015847406	0.008222873
1 B 2 b	Gaseous Fuels	Carbon dioxide	1422419.85	1351144.119	0.216526018	1.144739224	3.19217E-08
1 B 2 b	Gaseous Fuels	Methane	6782343.439	6912699.44	0.067882637	0.358884894	0.073733829
1 B 2 c		Carbon dioxide	291499.8474	305959.8014	0.002808999	0.014850738	0.008364425
1 B 2 c		Methane	1427.856843	1445.448719	7.94784E-06	4.2019E-05	3.50875E-05
1 B 2 c		Nitrous oxide	1102.340898	903.2737373	0	0	0
2 A 1		Carbon dioxide	15145810	12312751.71	0.042058713	0.222357843	0.045683992
2 A 2		Carbon dioxide	6176470.195	4539452.724	0.051892188	0.274345891	0.056365071
2 A 4		Carbon dioxide	379399.64	224836.21	0.012003899	0.06346274	0.013038583
2 A 7 ceramics		Carbon dioxide	531112.9	318460.796	0.010357156	0.054756665	0.011249898
2 A 7 glass		Carbon dioxide	695617.0705	679082.3524	0.004648372	0.024575218	0.005049042
2 B 1		Carbon dioxide	5745000	6845000	0.004117098	0.021766453	0.002439259
2 B 2		Nitrous oxide	3384400.15	3309024.088	0.018002198	0.095174806	0.019553909
2 B 3		Nitrous oxide	18804600	8569989.567	0.193750302	1.024327571	0.21045074
2 B 4		Carbon dioxide	443160	16146	0.000243623	0.001287998	0.000264623
2 B 5		Carbon dioxide	6888160.698	8749583.962	0.203804193	1.077480926	0.057506641
2 B 5		Methane	252.85995	310.93083	5.02019E-06	2.6541E-05	5.45291E-06
2 B 5		Nitrous oxide	292686.5	62000	0.009922517	0.052458799	0.005577213
2 C 1		Methane	3918.6	3532.434847	4.90924E-05	0.000259544	5.62873E-05
2 C 1		Carbon dioxide	22711891.28	11669490.61	0.114403767	0.604834843	0.124264878
2 C 1		Nitrous oxide	27613.095	10624.47615	0.0008076	0.004269654	0.000877212
2 C 2		Carbon dioxide	429000	7920	0.000426628	0.002255514	0.000463401
2 C 3		Carbon dioxide	1011923.117	398753.9	0.006395847	0.033813845	0.006947142
2 C 3		CF4	1358500	216521.5	0.003465223	0.018320093	0.000250927
2 C 3		C2F6	193200	30691.2	0.000492166	0.002602006	3.55681E-05
2 C 4		Sulphur hexafluoride	C	C	0.002998761	0.01585398	0.003253709

IPCC Source	Fuel Category	Gas	Base year emissions	2009 emissions	Combined Uncertainty as % of total nat. emissions in 2009	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO ₂ equi.]	[Gg CO ₂ equi.]	[%]	[%]	[%]
2 C 5		HFC-134a	C	C	0.000484202	0.0025599	0.000525282
2 E		HFC-23	C	C	0.007739564	0.040917864	0.008406681
2 E		HFC-134a	C	C	0.000146372	0.000773846	0.000158989
2 E		HFC-227ea	C	C	7.02365E-05	0.000371329	7.62906E-05
2 E		Sulphur hexafluoride	167300	71525.052	0.000763128	0.004034536	0.000828906
2 F		HFC-125	78985.18578	1812522.328	0.024084235	0.127329587	0.026160192
2 F		HFC-134a	C	C	0.048094946	0.254270466	0.038897434
2 F		HFC-143a	56465.16293	2384540.459	0.036997535	0.195600188	0.040186563
2 F		HFC-152a	C	C	0.000119656	0.000632601	5.35413E-07
2 F		HFC-227ea	C	C	0.000421631	0.002229099	0.000157616
2 F		HFC-23	21732.81667	260175.9941	0.003670358	0.019404608	0.001489389
2 F		HFC-236fa	0	7749.0756	7.93316E-05	0.000419414	8.61696E-05
2 F		HFC-245fa	C	C	0	0	7.28173E-06
2 F		HFC-32	206.0004344	60127.49769	0.000514501	0.002720085	0
2 F		HFC-365mfc	C	C	0	0	6.82183E-06
2 F		HFC-43-10mee	C	C	3.88365E-06	2.05323E-05	4.21841E-06
2 F		C2F6	104096.6666	66644.22494	0.000671767	0.003551527	0.00072967
2 F		C3F8	C	C	0.000999358	0.005283449	0.001085498
2 F		c-C4F8	0	1449.436895	1.88668E-05	9.97458E-05	2.0493E-05
2 F		CF4	85717.33333	56235.54953	0.00059599	0.003150903	2.05647E-05
2 F		Sulphur hexafluoride	C	C	0.021176459	0.111956629	0.005201415
3		Carbon dioxide	2552000	1471215.493	0.012424377	0.065685742	0.013495305
3 D		Nitrous oxide	1924563.105	314559.5048	0.016026207	0.084728052	0.006966868
4 A 1 a	Dairy cows	Methane	14135123.66	11326342.98	0.488787715	2.584144274	0.530919103
4 A 1 b	Cattle or dairy cows	Methane	11827199.65	8434982.284	0.224167333	1.185137664	0.243471446
4 A 2	Other animals	Methane	1331446.47	1189418.233	0.03485154	0.184254647	0.037858421
4 B 1 a	Dairy cows	Methane	2668966.147	2573485.625	0.111058632	0.587149635	0.120631406
4 B 1 b	Cattle and dairy cows	Methane	1589612.951	1045955.317	0.029919397	0.158179178	0.032504344
4 B 13	Dairy cows	Nitrous oxide	1159062.486	961706.9905	0.083982957	0.444004769	0.091221925
4 B 13	Cattle or dairy cows	Nitrous oxide	1137325.387	770178.0368	0.039734104	0.210067999	0.043159053
4 B 13	Other animals	Nitrous oxide	79197.68509	83135.72636	0.007278957	0.038482707	0.007907276
4 B 13	Poultry	Nitrous oxide	37671.99571	48702.04908	0.00293171	0.015499493	0.003184833
4 B 13	Swine	Nitrous oxide	360451.7741	366575.6044	0.024870705	0.131487532	0.027014181
4 B 2	Other animals	Methane	99432.15525	127657.7894	0.002727748	0.014421178	0.002963319
4 B 8	Swine	Methane	2259754.384	2280809.395	0.074844266	0.395689942	0.082779517
4 D		Nitrous oxide	30785175.59	27167550.49	1.628156318	8.607808054	1.768496356
4 D		Nitrous oxide	2075177.768	1580493.589	0.343936547	1.818338786	0.373582391
4 D 1		Nitrous oxide	17194611.86	14745196.8	5.544813383	29.31456197	6.022752332
5 A		Carbon dioxide	-70053371.82	-25421591.15	0.278309633	1.471379544	0.013515398
5 A		Methane	9084.069433	4617.351371	0.000187593	0.000991773	0.000203762
5 A		Nitrous oxide	45479.65116	45646.15398	0.002659863	0.01406228	0.002889132
5 B		Carbon dioxide	28639058.34	27103909.95	1.794242535	9.485879931	1.948898487

IPCC Source	Fuel Category	Gas	Base year emissions	2009 emissions	Combined Uncertainty as % of total nat. emissions in 2009	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO ₂ equi.]	[Gg CO ₂ equi.]	[%]	[%]	[%]
5 B		Nitrous oxide	719735.4171	357626.1769	0.024300125	0.128470966	0.026394691
5 C		Carbon dioxide	4699098.454	10720847.47	0.691187625	3.654200975	0.750765011
5 D		Carbon dioxide	2163835.288	2408290.967	0.174061395	0.920235399	0.189064735
5 E		Carbon dioxide	2485453.255	2278574.839	0.123862848	0.654843525	0.13453929
5 G		Carbon dioxide	116784.7178	65419.08596	0.005234855	0.027675861	0.005686077
6 A		Methane	38598000	8463000	0.112868636	0.596718844	0.122597425
6 B		Methane	2226211.516	80896.41101	0.006473355	0.034223618	0.00703133
6 B		Nitrous oxide	2223526.4	2303924.803	0.184360759	0.974686526	0.20025186
6 D		Methane	49777.896	554483.244	0.024864714	0.131455858	0.027007945
6 D		Nitrous oxide	13982.612	357472.408	0.018826532	0.099532932	0.020449297
Total			1,220,303.913	937,262.144	6.566	100.000	7.104202179

Uncertainties for source categories have been determined successively, within the framework of UBA sections' data deliveries for current emissions reporting. On the other hand, external experts have carried out additional uncertainties determination, in research projects, for source categories for which no uncertainties information, or incomplete information, has been available to date. The results of such uncertainties analysis have been integrated within the current report.

The uncertainties in the source category Agriculture (CRF 4) were estimated by experts of the Johann Heinrich von Thünen Institute (vTI).

Current work planning calls for Tier 2 uncertainties analysis to be carried out every three years. Uncertainties determination pursuant to Tier 1 will be carried out, and reported, every year.

24 REFERENCES

- AGEB, 2003: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanzen der Bundesrepublik Deutschland - Jahre 1990-1999, Verlags- und Wirtschaftsgesellschaft der Elektrizitätswerke, Frankfurt a. M.
- AGEB, 2002: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Sonderauswertung für das UBA zur Darstellung von ausgewählten Energieverbräuchen in der Struktur der Energiebilanz vor 1995 für Zeitreihen von 1995 bis 1999 (unveröffentlicht)
- AGEB, 2009: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland
URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63>,
(Aufruf: 19.10.2009), Köln, Berlin.
- AGEB, 2010: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland
URL: <http://www.ag-energiebilanzen.de/viewpage.php?idpage=63>,
(Aufruf: 25.08.2010 & 10.11.2010), Köln, Berlin.
- AMD, 2002/2003: Amd Saxony LLC&Co. KG, Dresden, Umweltbericht. S. 16
- ANKEN, T., P. WEISSKOPF, U. ZIHLMANN, H. FORRER, J. JANSKA & K. PERHACOVA (2004): Long –term tillage system effects under moist cool conditions in Switzerland; Soil & Tillage Research 78/2, 171-183 et al 2004.
- ARBEITSGRUPPE BODEN (1994): Bodenkundliche Kartieranleitung (KA. 4). 4. Aufl; S. 392; verbesserte und erweiterte Auflage, Hannover
- ARBEITSGRUPPE BODEN (2005): Bodenkundliche Kartieranleitung. 5. verbesserte und erweiterte Auflage, Hannover
- ATV, 2004: ATV-DVWK-M 374: Produktionsspezifische Abwässer und Abfälle aus der Glas- und Mineralfaserindustrie, ATV-DVWK Deutsche Vereinigung der Wasserwirtschaft, Abwasser und Abfall e.V., 08/2004
- AUGUSTIN, J. (2001): Emission, Aufnahme und Klimarelevanz von Spurengasen. - In: Succow, M. & H. Joosten [Hrsg.]: Landschaftsökologische Moorkunde. 2., völlig Neubearb. Aufl.: 28-38; Stuttgart (Schweizerbart'sche Verlagsbuchhandlung).
- AUST, o.J.: Vorlesungsscript TC-7: Abwasserbehandlung, siehe http://www.fh-nuernberg.de/tc/lab-aust/lim/wasserbeh_1_kap5_3.pdf
- BAFA, 2010: Bundesamt für Wirtschaft und Ausfuhrkontrolle, Amtliche Mineralöl- und Mineralgasdaten für die Bundesrepublik Deutschland,
URL: http://www.bafa.de/bafa/de/energie/mineraloel_rohstoffe/amtliche_mineraloel_daten/index.html, (Aufruf: 10.11.2010), Eschborn.
- BAST, 2007: Bundesanstalt für Straßenwesen: Unterreihe Verkehrstechnik; V 164: "Straßenverkehrszählung 2005: Ergebnisse", Thorsten Kathmann, Hartmut Ziegler, Bernd Thomas; 62 Seiten; Bergisch Gladbach, 2007
- BAST, 2008: Bundesanstalt für Straßenwesen: Unterreihe Verkehrstechnik; V 166: Verkehrsentwicklung auf Bundesfernstraßen 2006, Arnd Fitschen, Ingo Koßmann, 239 Seiten; Bergisch Gladbach, 2008

- BATZ, 1995: Kokereien und Produktemissionen. Mündliche Mitteilung. Umweltbundesamt.
- BDZ 1995: Sonderauswertung des Bundesverbandes der deutschen Zementindustrie, erstellt für das UBA für die Jahre 1990-1994
- BGR (1997): Digitale Bodenübersichtskarte der BRD (BUEK 1000); Maßstab: 1:1.000.000; Hannover
- BENNDORF, R., 1999: Situation in Deutschland, ACCC-Workshop „N₂O und das Kyoto-Ziel“, Umweltbundesamt (Berlin), Wien
- BLANK, R.R. & M.A. FORSBERG (1989): Cultivated and adjacent virgin soils in northcentral South Dakota: I. Chemical and physical comparisons. Soil Science Society of America Journal, 53, 1484-1490
- BLE (Bundesanstalt für Landwirtschaft und Ernährung), 2008. Waldbrandstatistik der Bundesrepublik Deutschland für das Jahr 2008.
- BMBF, 1997: Verbundvorhaben des Umweltbundesamtes mit dem BMBF: Deponiekörper, Förderkennzeichen 1460799A bis G (Teilvorhaben), Projektträger Abfallwirtschaft und Altlasten im Umweltbundesamt Berlin, Koordinierung Fachgebiet Abfall- und Siedlungswasserwirtschaft, Bergische Universität - Gesamthochschule Wuppertal
- BMLFUW, 2005: Abschätzung der Auswirkungen des Tanktourismus auf den Treibstoffverbrauch und die Entwicklung der CO₂-Emissionen in Österreich.; Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft; Wien; 2005
- BMU, 1990: Eckwerte der ökologischen Sanierung und Entwicklung in den neuen Ländern, Bonn
- BMVEL (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft) (Hrsg.), 2001. Aufnahmeanweisung für die Bundeswaldinventur II (2001 - 2002), 2. korrigierte, überarbeitete Ausgabe, Mai 2001, Bonn, 108 S.
- BMVEL (2003): Statistisches Jahrbuch über Ernährung Landwirtschaft und Forsten der Bundesrepublik Deutschland 2003. 47. Jahrgang, 557 S., Landwirtschaftsverlag GmbH, Münster-Hiltrup
- BMELV (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft) (Hrsg.), 2005. Die zweite Bundeswaldinventur – BWI²: Der Inventurbericht. Bonn, 231 S.
- BMELV, 2007: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland. Landwirtschaftsverlag GmbH, Münster-Hiltrup
- BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz) (Hrsg.), 2008. Aufnahmeanweisung für die Inventurstudie 2008 (IS08) (2008), Bonn, 55 S.
- BMVg, 2010: Bundesministerium der Verteidigung: Energieeinsatz zur Wärmeversorgung der Bundeswehr (unveröffentlicht).
- BPB, 2002: Bundeszentrale für politische Bildung. Projektgruppe Zukunft der Wirtschaft, Die Zukunft der Wirtschaft, Landwirtschaft und Ernährung, herausgegeben von Margarete Wohlan

- BOUMA, J. & F.D. HOLE (1971): Soil structure and hydraulic conductivity of adjacent virgin and cultivated pedons at two sites: A typic argiudoll (silt loam) and a typic eutrochrept (clay). *Soil Science Society of America Proceedings*, 35, 316 – 319
- BOWMAN, R.A., J.D. REEDER & R.W. LOBER (1990): Changes in soil properties in a central plains rangeland soil after 3, 20, and 60 years of cultivation. *Soil Science* 150, 851-857
- BURKE, I.C., W.K. LAUENROTH & D.P. COFFIN (1995): Soil organic matter recovery in semiarid grasslands: implications for the conservation reserve program. *Ecological Applications*, 5, 793-801
- BURSCHEL, P.; KÜRSTEN, E.; LARSON, B.C. (1993): Die Rolle von Wald und Forstwirtschaft im Kohlenstoffhaushalt - eine Betrachtung für die Bundesrepublik Deutschland. *Forstliche Forschungsberichte München, Forstwissenschaftliche Fakultät d. Universität München u. Bayrische Landesanstalt f. Wald u. Forstwirtschaft, Freising*, 135 S.
- BUYANOVSKY, G.A., C.L. KUCERA & G.H. WAGNER (1987): Comparative analyses of carbon dynamics in native and cultivated ecosystems. *Ecology*, 68, 2023-2031
- BV Glas, 2009: Jahresbericht des Bundesverband Glasindustrie e.V., mit statistischem Anhang
- BV Kalk, 2010 (Bundesverband der deutschen Kalkindustrie e.V.): Kalk Daten nationaler Inventarbericht; per E-Mail an das UBA übermittelt.
- BVE, 2009: Bundesvereinigung der Deutschen Ernährungsindustrie e.V. Internetseiten, URL: www.bve-online.de
- BYRNE, K.A., B. Chojnicki, T.R. Christensen, M. Drösler, A. Freibauer, T. Friborg, S. Frolking, A. Lindroth, J. Mailhammer, N. Malmer, P. Selin, J. Turunen, R. Valenti & L. Zetterberg, 2004: EU Peatlands: Current Carbon Stocks and Trace Gas Fluxes. CarboEurope-GHG Report 4/2004. Specific Study, Tipo-Lito Recchioni, Viterbo, October 2004, S.58.
- CAIRNS, M.A.; BROWN, S.; HELMER, E.H.; BAUMGARDNER, G.A., 1997: Root biomass allocation in the world's upland forests. *Oecologia*, Vol. 111 (1), pp. 1-11
- CAMBARDELLA, C.A. & E.T. ELLIOT (1992): Particulate soil organic-matter changes across a grassland cultivation sequence. *Soil Science Society of America Journal*, 56, 777-783
- CAMBARDELLA, C.A. & E.T. ELLIOT (1993): Carbon and nitrogen distribution in aggregates from cultivated and native grassland soils. *Soil Science Society of America Journal*, 57, 1071-1076
- CAMPEL et al. (1989): *Soil Tillage Res.*, 14:39-52
- CHAN AND MEAD (1988): Surface physical properties of sandy loam soil under different tillage practices. *Australian Journal of Soil Research*, 26, 549-559
- CONANT, R.T., K. PAUSTIAN & E.T. ELLIOTT (2001): Grassland management and conversion into grassland: effects on soil carbon. *Ecological Applications*, 11, 343-355

- CORINAIR, 2006 - EMEP/CORINAIR Emission Inventory Guidebook - 2006, EEA technical report No. 11/2006; Dezember 2006, Kopenhagen 2006
URL: <http://www.eea.europa.eu/publications/EMEP/CORINAIR4>
- CLODIC., D & BEN YAHIA, M. 1997: Centre d'Energétique, Ecole des Mines de Paris: New Test Bench for Measuring Leak Flow Rate of Mobile Air Conditioning Hoses and Fittings. Earth Technology Conference, Baltimore.
- DÄMMGEN, 2005: Dämmgen, U.: Statistical Data for Animal Numbers in German Emission Inventories. Landbauforschung Völkenrode, special issue 291, 223-229
- DÄMMGEN, U.; HUTCHINGS N.J., 2005: The assessment of emissions of nitrogen species from agriculture using the methodology of the atmospheric emission inventory guidebook. In: Kuczyński T, Dämmgen U, Webb J, Myczko A (eds) Emissions from European agriculture. Wageningen Academic Publishers, Wageningen. pp 51-62
- DÄMMGEN et al, 2002: Dämmgen, U., Lüttich, M., Döhler, H., Eurich-Menden, B., Osterburg, B.: GAS-EM – A Procedure to Calculate Gaseous Emissions from Agriculture. Landbauforschung Völkenrode 52, S. 19-42.
- DÄMMGEN et al, 2009a: Dämmgen, U.; Haenel, H.-D.; Rösemann, C.; Conrad, J.; Lüttich, M.; Döhler, H.; Eurich-Menden, B.; Laubach, P., Müller-Lindenlauf, M.; Osterburg, B.; Strogies, M.: Calculations of Emissions from German Agriculture - National Emission Inventory Report (NIR) 2009 for 2007. vTI Agricultural and Forestry Research, Special Issue 324, 9-385
- DAV, 2010: Deutscher Asphaltverband e.V., Schieffelingsweg 6, 53123 Bonn, Veröffentlichung zur Asphaltproduktion in Deutschland, <http://www.asphalt.de/site/startseite/aktuelles/asphaltproduktion/> (Dokument asphaltp09.pdf), Stand August 2010
- DAVIDSON, E.A. & I.L. ACKERMAN, 1993: Changes in soil carbon inventories following cultivation of previously untilled soils. Biogeochemistry, 20,161-193
- DBU, 2002: Vogt, R., Knappe, F., Giegrich, J., Detzel, A., IFEU-Institut für Energie und Umweltforschung Heidelberg (Hrsg.): Ökobilanz Bioabfallverwertung. Untersuchung zur Umweltverträglichkeit von Systemen zur Verwertung von biologisch-organischen Abfällen. Initiativen zum Umweltschutz, Band 52. Erich Schmidt Verlag, Berlin 2002
- DEBRIV, 2004: Deutscher Braunkohlen-Industrie-Verein e.V., Mitteilung vom 15. September 2004 an das IKP Stuttgart.
- DEGRYZE, S., J. SIX, K. PAUSTIAN, S.J. MORRIS, E.A. PAUL & R. MERCKX (2004) : Soil organic carbon pool changes following land-use conversions. Global change Biology, 10, 1120-1132
- DIE LANDWIRTSCHAFT (1998): Lehrbuch für Landwirtschaftsschulen. Band 1: Pflanzliche Erzeugung. 11. Aufl. BLV-Verlagsgesellschaft mbH, München
- DGE, 2000: Deutsche Gesellschaft für Ernährung e.V.: Ernährungsbericht 2000, ISBN 3-921 606-40-3
- DGMK, 1992: Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V.: Forschungsbericht 448-2 - Ansatzpunkte und Potentiale zur Minderung des Treibhauseffektes aus Sicht der fossilen Energieträger, Hamburg, Seite II-89

- DIE VERBRAUCHER INITIATIVE e.V., 2005: Distickstoffmonoxid, (Online Dokument) <http://www.zusatzstoffe-online.de/html/zusatz.php3?nr=942> , Zugriff Mai 2005
- DIETER, M., ELSASSER, P., 2002: Carbon Stocks and Carbon Stock Changes in the Tree Biomass of Germany's Forests. In: Forstwissenschaftliches Centralblatt (121. Jahrgang), S. 195-210. Berlin: Blackwell Wissenschafts-Verlag
- DIN, 2003: DIN EN 1279-3: Glas im Bauwesen - Mehrscheiben-Isolierglas - Teil 3: Langzeitprüfverfahren und Anforderungen bezüglich Gasverlustrate und Grenzabweichungen für die Gaskonzentration; Deutsche Fassung EN 1279-3:2002
- DIN, 2004: Deutsches Institut für Normung e. V. (DIN). DIN 1343. Referenzzustand, Normzustand, Normvolumen; Begriffe und Werte. Internetseite mit Recherchefunktionen. URL: <http://www2.din.de>. Berlin.
- DIW, 1991: Deutsches Institut für Wirtschaftsforschung, Entwicklung des Energieverbrauchs und seiner Determinanten in der ehemaligen DDR. Von Hans-Joachim Ziesing. Untersuchung im Auftrag des Bundesministers für Wirtschaft. Im Unterauftrag: Institut für Energetik (IfE), Leipzig; Institut für Wirtschaftswissenschaften der Akademie der Wissenschaften, Berlin; Staatliche Vorratskommission für nutzbare Ressourcen der Erdkruste, Berlin. Berlin, April 1991
- DIW, 2002: Rieke, H. (DIW): Fahrleistungen und Kraftstoffverbrauch im Straßenverkehr; in: DIW Wochenbericht Nr. 51-52/2002; Berlin, Dezember 2002; Ergebnisse auch kontinuierlich veröffentlicht in „Verkehr in Zahlen“
- DLG, 2005: Deutsche Landwirtschafts-Gesellschaft (ed.) Bilanzierung der Nährstoffausscheidungen landwirtschaftlicher Nutztiere. Arbeiten der DLG/Band 199. DLG-Verlag, Frankfurt/Main. 69 pp
- DMT 2005: Freundliche persönliche Mitteilung von Herrn Meiners, Deutsche Montan Technologie. 28.09.2005. Gelsenkirchen.
- EC, 2006a: European Commission, Joint Research Centre, Institute for Prospective Technological Studies: Integrated Pollution Prevention and Control – Reference Document on Best Available Techniques in the Production of Polymers. October 2006. Sevilla, Spain.
- EC, 2007: European Commission, Joint Research Centre, Institute for Prospective Technological Studies: Integrated Pollution Prevention and Control – Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Solids and Others industry. October 2006. Sevilla, Spain.
- EC, 2010: Fleet Register der Europäischen Kommission;
URL:<http://ec.europa.eu/fisheries/fleet/index.cfm?method=Search.SearchAdvanced&country=DEU>, (Aufruf 10.11.2010)
- ELLIS JL, Kebreab E, Odongo NE, McBride BW, Okine EK, France J (2007) Prediction of Methane Production from Dairy and Beef Cattle. J Dairy Sci 90, 3456-3466
- EMEP, 2003: Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, 3rd Edition September 2003 UPDATE, EEA, Copenhagen, 2003

- EMEP, 2005a: European Environment Agency: EMEP/CORINAIR Emission Inventory Guidebook - 2005. Technical report No 30., Stand: 31.12.2005
URL: reports.eea.europa.eu/EMEPCORINAIR4/en/
- EMEP, 2006: Atmospheric Emission Inventory Guidebook. Chapter 1090 Manure Management Regarding Nitrogen Compunds. Draft.
- EMEP, 2009: EMEP (2009) -EMEP/EEA air pollutant emission inventory guidebook – 2009, Technical Report No 6/2009. <http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009>
- EUROCONTROL, 2004 – The Advanced Emission Model (AEM3) - Validation Report, Jelinek, F., Carlier, S., Smith, J., EEC Report EEC/SEE/2004/004, Brüssel 2004. URL: http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2004_016.html
- EUROCONTROL, 2006 – The Advanced Emission Model (AEM3) - Validation Report, Jelinek, F., Carlier, S., Smith, J., EEC Report EEC/SEE/2004/004, Brüssel 2004
URL: http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2004_016.html
http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2006_030.html
- FAO, 1998: World Reference Base for Soil Resources. Rome, Italy.
- FAO, 2007: FAO Statistical Yearbook 2004 Vol.1/1 URL: http://www.fao.org/statistics/yearbook/vol_1_1/index.asp. September 2007
- FAO, 2009: FAO Statistical Yearbook 2007-2008 ; Table D1: Dietary energy protein and fat consumption URL: <http://www.fao.org/economic/ess/publications-studies/statistical-yearbook/fao-statistical-yearbook-2007-2008/en/>
- FAO, o.J.: Tabellen auf Homepage unter <http://faostat.fao.org/default.jsp> und persönlicher Austausch UBA mit FAO
- FAUSTZAHLEN (1993): Faustzahlen für Landwirtschaft und Gartenbau. 12th ed., Landwirtschaftsverlag, Münster, 1993
- FREIBAUER, A. (2003): Regionalised inventory of biogenic greenhouse gas emissions from European agriculture. European Journal of Agronomy 19(2): 135-160
- FHG ISI, 1993: Fraunhofer-Institut für Systemtechnik und Innovationsforschung: Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland: Emissionsbilanz, Identifikation von Forschungs- und Handlungsbedarf sowie Erarbeitung von Handlungsempfehlungen ; Phase 1, UBA-Berichte 93/09, FKZ 10402682, E. Schmidt-Verlag Berlin, 1993
- FISCHER, 1997: Klimawirksame Emissionen durch PKW-Klimaanlagen. Diplomarbeit an der TU Berlin, FB 10, ISS-Fahrzeugtechnik.
- FISCHER, D. von, 1988: Hinweise für den Feldfutterbau sowie den Zwischenfruchtbau zur Futternutzung und Gründüngung. 11. Auflage. Landwirtschaftskammer Rheinland, Bonn.
- FRANZLUEBBERS, A.J., N. NAZIH, J.A. STUEDMANN, J.J. FUHRMANN, H.H. SCHOMBERG & P.G. HARTEL (1999): Soil carbon and nitrogen pools under low- and high-endophyte-infected tall fescue. Soil Science Society of America Journal, 63, 1687-1694

- FRANZLUEBBERS, J.A. STUEDMANN, H.H. SCHOMBERG & S.R. WILKINSON (2000): Soil organic C and N pools under long-term pasture management in the Southern Piedmont USA, *Soil Biology & Biochemistry*, 32, 469 – 478
- FRAVER et. al 2002, Fraver, S.; Wagner, R.G.; Day, M.; 2002. Dynamics of coarse woody debris following gap harvesting in the Acadian forest of central Main, U.S.A. *Can. J. For. Res.* 32, 2094-2105.
- GDA, 2009: Gesamtverband der Aluminiumindustrie e.V. – Fachverband Primäraluminium: Vorab-Auszug aus dem Monitoringbericht über die Fortschritte bei der Reduktion der CF4/C2F6 Emissionen der deutschen Primäraluminiumindustrie für das Jahr 2008, Mitteilung per E-Mail vom 18.09.2009 von Herrn Rainer Buchholz (Wirtschaftsvereinigung Metalle e.V.) via Herrn Salomon (BMU).
- GEBHART, D.L., H.B. JOHNSON, H.S. MAYEUX & H.W. POLLEY (1994): The CRP increases soil organic carbon. *Journal of Soil and Water Conservation*, 49, 488-492
- GENSIOR, A. & J. ZEITZ (1999): Einfluss einer Wiedervernässungsmaßnahme auf die Dynamik chemischer und physikalischer Bodeneigenschaften eines degradierten Niedermoores. *Archiv für Naturschutz und Landschaftsforschung*, 38, S. 267 – 302
- GICON, 2008: Implementierung der Bilanz der Emissionsursachen auf Basis der MESAP-Datenbank Bachmann, Thomas; Kalies, Heiko GICON, Großmann Ingenieur Consult GmbH Niederlassung Leipzig 2008
- GUO, L.B. & R.M. GIFFORD (2002): Soil carbon stocks and land use change: a meta analysis. *Global Change Biology*, 8, 345-360
- HAENEL et al, 2010: Haenel, H.-D.; Rösemann, C.; Dämmgen, U.; Döhler, H.; Eurich-Menden, B.; Laubach, P., Müller-Lindenlauf, M.; Osterburg, B.; Calculations of Emissions from German Agriculture - National Emission Inventory Report (NIR) 2010 for 2008. In Vorbereitung für vTI Agriculture and Forestry Research (Landbauforschung).
- HART, P.B.S., J.A. AUGUST & C.W. ROSS (1988): Some biochemical and physical properties of Tokomaru silt loam under pasture and after 10 years of cereal cropping. *New Zealand Journal of Agricultural Research*, 31, 77-86
- HENRICHSMEYER et al, 1996: Henrichsmeyer, W.; Cypris, Ch.; Löhe, W.; Meuth, M.; Isermeyer F; Heinrich, I.; Schefski, A.; Neander, E.; Fasterding, F.; Neumann, M.; Nieberg, H.: Entwicklung des gesamtdeutschen Agrarsektormodells RAUMIS96. Endbericht zum Kooperationsprojekt. Forschungsbericht für das BMELF (94 HS 021), Bonn, Braunschweig
- HOBBS et al., 2004: Hobbs P.J.; Webb J.; Mottram T.T.; Grant B.; Misselbrook T.M.: Emissions of volatile organic compounds originating from UK livestock agriculture. *J Science of Food and Agriculture* 84, 1414-1420
- HÖPER, H. (2002): Carbon and nitrogen mineralization rates in German agriculturally used fenlands. In: Broll, G. Merbach, W. und E.-M. Pfeiffer (Hrsg.): *Wetlands in Central Europe. Soil organisms, soil ecological processes, and trace gas emissions*. Springer, Berlin, 149-164.

- HORNE, D.J., C.W. ROSS & K.A.HUGHES (1992): Ten years of a maize/oats rotation under three tillage systems on a silt loam in New Zealand. Soil & Tillage Research, 22, 131-143
- HVG, 2008: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung. Teilvorhaben 02: Bereitstellung aktueller Emissionsdaten für die Glas- und Mineralfaserindustrie., Forschungsbericht in Veröffentlichung
- IFE, 1991: IfE Leipzig GmbH, Energiebilanz 1990 für die neuen Bundesländer. Von Jochen Hesselbach und Mitarbeit von Bernd Lemnitz, Elke Lindner, Hans-Albert Müller und Ursula Zehrfeld. Untersuchung im Auftrag des Bundesministers für Wirtschaft, Leipzig 1991
- IFEU, 2002, Knörr, W. et al, IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Aktualisierung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen aus dem motorisierten Verkehr in Deutschland 1980 bis 2020; sowie TREMOD 3.0 ; im Auftrag des Umweltbundesamtes, FKZ 201 45 112; Berlin 2002
- IFEU, 2003a: Detzel, A., Vogt, R., Fehrenbach, H., Knappe, F., Gromke, U., IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien. Teil Abfall/Abwasser, Februar 2003
- IFEU, 2009: Helms, H., Lambrecht, U., Knörr, W. , IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Aktualisierung des Modells TREMOD-Mobile Machinery , im Auftrag des Umweltbundesamtes, FKZ 360 16 018, Heidelberg, Korrigendum 11.02.2010.
- IFEU, 2010: Knörr, W. et al, IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030, sowie TREMOD 5.11, im Auftrag des Umweltbundesamtes, FKZ 3707 45 101, Berlin.
- IFEU & INFRAS, 2009: IFEU – Institut für Energie- und Umweltforschung Heidelberg gGmbH und INFRAS Zürich: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland, FKZ 360 16 023, Heidelberg & Zürich.
- IFEU & ÖKO-INSTITUT, 2010: Implementierung eines eigenständigen Moduls zur Berechnung des Flugverkehrs in das bestehende TREMOD-System, vorläufiger Endbericht zum F+E-Vorhaben 360 16 029, Berlin & Heidelberg, November 2010
- IGZ (2007): IGZ – Institut für Gemüse- und Zierpflanzenbau, Großbeeren/Erfurt. Düngung im Freilandgemüsebau – Datenbasis für eine erfolgreiche Düngung im Freilandgemüsebau (2. Auflage). Berlin/Bonn.
http://www.igzev.de/files/Dueng_im_FGB.pdf
- IHORI, T., I.C. BURKE, W.K. LAUENROTH & D.P. COFFIN (1995): Effects of cultivation and abandonment on soil organic matter in north eastern Colorado. Soil Science Society of America Journal, 59, 1112-1119
- IKP, 1996: Institut für Kunststoffprüfung und Kunststoffkunde (IKP), Universität Stuttgart: Ganzheitliche Bilanzierung von Dachbahnen aus Bitumen. In elektronischer Form über die UBA-Fachbibliothek zu beziehen (Signatur UM 381318)

- INFRAS, 2004: Handbuch Emissionsfaktoren des Straßenverkehrs 2.1- Dokumentation, Bern, 188.8.2004
- IPCC – Intergovernmental Panel on Climate Change (1996): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 1 - 3. Greenhouse Gas Inventory Reporting Instructions (Vol. 1), Workbook (Vol. 2), Reference Manual (Vol. 3). IPCC WGI Technical Support Unit, Bracknell
- IPCC, 1996a: Intergovernmental Panel on Climate Change: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Workbook, 1996
- IPCC, 1996b: Intergovernmental Panel on Climate Change: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Reference Manual, 1996
- IPCC, 1996c: Intergovernmental Panel on the Climate Change, Emission Inventory Guidebook, 1996: B 465, B466, B 644
- IPCC, 1999: Intergovernmental Panel on Climate Change: Aviation and the Global Atmosphere, Kapitel 9, Aircraft Emissions: Current Inventories and Future Scenarios, Cambridge University Press, 1999
- IPCC, 2000: Intergovernmental Panel on Climate Change, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC Secretariat, 16th Session, Montreal, 1-8 May 2000
<http://www.ipcc-nggip.iges.or.jp/public/gp/english/>
- IPCC, 2001: Intergovernmental Panel on Climate Change: Corrigendum of Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, <http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm>
- IPCC, 2003: Intergovernmental Panel on Climate Change: Good Practice Guidance for Land Use, Land-Use Change and Forestry. vi + 307 S.
- IPCC, 2004: Intergovernmental Panel on Climate Change: Synthesis and Assessment Report on the Greenhouse Gas Inventories submitted in 2004, Part I. FCCC/WEB/SAI/2004. Bonn.
- IPCC, 2006: Intergovernmental Panel on Climate Change: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual, Volume 4, 2006
- IPCC 2006a – Intergovernmental Panel on Climate Change: Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 3_ Mobile Combustion, S. 3.61;
URL: http://www.ipccnggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
- IPCC 2006b – Intergovernmental Panel on Climate Change: Datenbank für Emissionsfaktoren des IPCC; URL: <http://www.ipcc-nggip.iges.or.jp/EFDB/main.php>
- IPCC, 2007: Intergovernmental Panel on Climate Change: IPCC Fourth Assessment Report: Climate Change 2007 URL:
http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html
- IPCC, et al, 1997: IPCC/UNEP/OECD/IEA: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Greenhouse Gas Inventory. Volume 3. Reference Manual. URL: <http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm>

- IVT 2004: Institut für angewandte Verkehrs- und tourismusforschung e.V.: Fahrleistungserhebung 2002, Teil: Begleitung und Auswertung. Untersuchung im Auftrag der Bundesanstalt für Straßenwesen, Projektnummer FE 82.201/2001. Heilbronn/Mannheim.
- JASTROW, J.D. & J. LUSSENHOP (1998): Contributions of integrating biological mechanisms to soil aggregate stabilization in restored prairie. *Soil Biology and Biochemistry*, 30, 905-916
- KNIGGE, W.; SCHULZ, H. (1966): *Grundriss der Forstbenutzung*. Paul Parey Verlag, Hamburg und Berlin, 584 S.
- KÖNIG G, BRUNDA M, PUXBAUM H, HEWITT CN, DUCKHAM SC, RUDOLPH J, 1995: Relative contribution of oxygenated hydrocarbons to the total biogenic VOC emissions of selected Mid-European agricultural and natural plant species. *Atmospheric Environment* 29, 861-874
- KÖNIG, H.-C., 2007. *Waldbrandschutz - Kompendium für Forst und Feuerwehr*, 1. Fachverlag Matthias Grimm, Berlin, 197 pp.
- KOLLMANN, F. 1982: *Technologie des Holzes und der Holzwerkstoffe*. Springer-Verlag, Berlin, Heidelberg, New York
- KURZ, W.A.; BEUKEMA, S.J.; APPS, M.J. (1996): Estimation of root biomass and dynamics for the carbon budget model of the Canadian forest sector, *Can. J. For. Res.*, Nr. 26 (11), pp.1973-1979
- LALE, Andreas 2000: *Langzeitemissionsverhalten von Deponien für Siedlungsabfälle in den neuen Bundesländern*. TU Dresden, Dissertation; Fakultät Forst-, Geo- und Hydrowissenschaften.
- LANGE, Hans-Jürgen, 1988: Kokereien. VOC aus Produktmissionen. Umweltbundesamt. Vermerk. Blatt 2.2.88 vorbehaltlich weiterer Recherchen. Angaben für 1990 – 1995, Angenommener VOC Anteil von 50%. Unveröffentlicht.
- LARIONOVA, A.A., L.N. ROZANOVA, I.V.YEVDOKIMOV, A.M. YERMOLAYEV, I.N. KURGANOVA & S.A. BLAGODATSKY (2003): Land-use change and management effects on carbon sequestration in soils of Russia's South Taiga zone. *Tellus*, 55B, 331-337
- LAWS, W.D. & D.D. EVANS (1949): The effects of long-time cultivation on some physical and chemical properties of two rendzina soils. *Soil Science Society of America Proceedings*, 14, 15-19
- LECHTENBÖHMER et al, 2005: Lechtenböhmer, S.; Harthan, R.; Dämmgen, U.; Strogies, M: Umsetzung des Inventarplanes und nationale unabhängige Überprüfung der Emissionsinventare für Treibhausgase. Teilvorhaben 01. Pilotstudie unabhängige bilaterale Inventarüberprüfung. Endbericht im Auftrag des Umweltbundesamts FKZ: 202 42 203. unveröffentlicht.
- LENK et al., 2005: *Auswirkungen des Tanktourismus auf das deutsche Steueraufkommen – eine finanzwissenschaftliche Bestandsaufnahme*; Leipzig, 2005
- LIEBIG, M., Tanaka, D., Wienhold, B. (2004): Tillage and cropping effects on soil quality indicators in the northern great plains *Soil & Tillage Research* 78/2, 131-143

- LINDE GAS GMBH, 2005: Aufschäumen von Molkereiprodukten; URL: <http://www.lindegas.at/international/web/lg/at/likelgatn.nsf/PrintView/63ED15ADE8FCF595C1256B7B004C6250> , Zugriff Mai 2005
- MANN, L.K. (1986): Changes in soil carbon storage after cultivation. *Soil Science*, 142, 279 -288
- MARTENS, D.A., T.E. REEDEY & D.T. LEWIS (2003): Soil organic carbon content and composition of 130-year crop, pasture and forest land-use managements. *Global Change Biology* 10,65-78
- MILLS et al., 2003, Alternative approaches to predicting methane emission from dairy cows. *J. Animal Sci.* pp 3141-3150.
- MNUW, 1990: Ministerium für Naturschutz, Umweltschutz und Wasserwirtschaft 1990): Umweltbericht der DDR – Informationen zur Analyse der Umweltbedingungen in der DDR und zu weiteren Maßnahmen, März 1990, statistische Angaben für das Aufkommen an Siedlungsabfall für das Gebiet der ehemaligen DDR Table 12, S. 56
- MÜLLER-BBM (2009a): „Inventarverbesserung 2008, Verbesserung und Ergänzung der aktuellen Inventardaten, IPCC-Kategorie (1996) 1.B.2 Diffuse Emissionen aus Erdöl und Erdgas“, Müller-BBM; Bericht Nr. M 76 595/4, UBA FKZ 360 16 012, 136 S.
- MÜLLER-BBM (2009b): „Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCC- und UNECE-Berichterstattung - Bereich Lageranlagen“, Müller-BBM Bericht Nr. M74 244/7, UBA FKZ 3707 42 103/01, 31 S.
- MÜLLER-USING, S.; BARTSCH, N.; 2009. Decay dynamic of coarse and fine woody debris of a beech (*Fagus sylvatica* L.) forest in Central Germany. *Eur J Forest Res*, 128, 287-296
- MÜLLER-WESTERMEIER et al, 2008: Die Witterung in Deutschland.
- MUNDEL, G. (1976): Untersuchungen zur Torfmineralisation in Niedermooren.- *Archiv Acker-, Pflanzenbau und Bodenkunde*. H. 10, 20: 669-679
- MURTY, D., M.U.F. KIRSCHBAUM, E. R.E. MCMURTIE & H. MCGILVRAY (2002): Does conversion of forest to agricultural land change soil carbon and nitrogen? a review of the literature. *Global Change Biology*, 8, 105-123
- MWV, 2006: Mineralölwirtschaftsverband, „Mineralölzahlen 2005“.
- MWV, 2010: Mineralölwirtschaftsverband: „Mineralölzahlen 2009“
URL: http://www.mwv.de/cms/front_content.php?idcat=10, (Aufruf: 10.11.2010), und
MWV Jahresbericht Mineralölzahlen 2009
URL: http://www.mwv.de/cms/upload/pdf/jahresberichte/2009_JB.pdf, (Aufruf: 10.11.2010), Berlin.
- NIELAND, S. (2009): Entwicklung und Bewertung einer Methode zur automatisierten Generalisierung des DLM-DE auf den Zielmaßstab des CORINE Land Cover-Datensatzes in Deutschland; Diplomarbeit Universität Innsbruck
- OECD/IEA, 2010: CO₂-Emissions from fuel combustion 2010 Edition, OECD & IEA, Paris, ISBN 9789264084278

- ÖKO-INSTITUT, 2004a: Arbeitsergebnisse aus dem F+E-Vorhaben 201 42 258 Unterstützung beim Aufbau eines Nationalen Systems für eine transparente Erhebung der Grundlagendaten und für die Emissionsberichterstattung entsprechend Artikel 5(1) des Kyoto-Protokolls, Auftragnehmer Öko-Institut, noch bis 15.10.2005 laufend (unveröffentlicht)
- ÖKO-INSTITUT, 2004b: Emissionen in Abwasser- und Schlammbehandlung. Arbeitspapier im Rahmen des dem F+E-Vorhaben 201 42 258 Unterstützung beim Aufbau eines Nationalen Systems für eine transparente Erhebung der Grundlagendaten und für die Emissionsberichterstattung entsprechend Artikel 5(1) des Kyoto-Protokolls (unveröffentlicht)
- ÖKO-INSTITUT, 2004c: CO₂ Emissionsfaktoren für die Erstellung der nationalen CO₂-Inventare. Teilbericht für den nationalen Inventarbericht 2004.
- ÖKO-INSTITUT, 2005 Analyse, Dokumentation und Überarbeitung der Bilanz der Emissionsursachen(BEU) / Verena Graichen, Ralph O. Harthan, Julia Repenning Weitere Titel Zeitnahe Erfassung und Bewertung des Energieumsatzes von stationären Quellen als Grundlage für strategische Entscheidungen, Bewertungen von Maßnahmen und die Erfüllung internationaler Berichtspflichten im Bereich Klimaschutz und Luftreinhaltung
- ÖKO-INSTITUT, 2006a: Kurzstudie - Stand und Entwicklung von Treibhausgasemissionen in den Vorketten für Erdöl und Erdgas für das Institut für wirtschaftliche Oelheizung e.V. (IWO), Endbericht erstellt von Uwe R. Fritsche. Darmstadt, Juli 2006.
- ÖKO-INSTITUT, 2006b: Datenaustausch zwischen Emissionshandel und Nationaler Klimaschutzberichterstattung, Abschlussbericht zum F+E-Vorhaben FKZ 205 41 521, Berlin, Dezember 2006. Unveröffentlicht.
- ÖKO-INSTITUT, 2007: Emissionsberichterstattung im Luftverkehr, vorläufiger Endbericht zum F+E-Vorhaben FKZ 201 42 258, Berlin, November 2007
- ÖKO-INSTITUT, 2009: Überarbeitung des Emissionsinventars des Flugverkehrs, vorläufiger Endbericht zum F+E-Vorhaben FKZ 360 16 019, Berlin, August 2009.
- ÖKO-INSTITUT / DIW 2007 (Öko-Institut – Institut für angewandte Ökologie e.V.) / DIW (Deutsches Institut für Wirtschaftsforschung) 2007: Dokumentation der Datenqualität von Aktivitätsdaten für die Berichte über Emissionen aus stationären Feuerungen im Rahmendes Nationalen Inventarberichtes und des Monitoring Mechanismus nach RLEG 99/296; Endbericht zum F&E-Vorhaben FKZ 204 41 132 i.A. des UBA; Berlin
- ÖKO-RECHERCHE, 1996, Büro für Umweltforschung und –beratung GmbH: Aktuelle und künftige Emissionen treibhauswirksamer fluorierter Verbindungen in Deutschland, im Auftrag des UBA, FKZ 106 01 074/01, Frankfurt am Main, 1996
- ÖKO-RECHERCHE, 2001: Emissionen des Kältemittels R-134a aus mobilen Klimaanlageen. Jährliche Emissionsraten von bis zu sieben Jahre alten PKW-Klimaanlagen, Gutachten für das Umweltbundesamt Berlin, Frankfurt.

- ÖKO-RECHERCHE, 2004: Emissionen, Aktivitätsraten und Emissionsfaktoren von fluorierten Treibhausgasen (F-Gasen) in Deutschland für die Jahre 1995-2002, Gutachten im Auftrag des Umweltbundesamtes, Berlin, FKZ 201 41 261/01. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennnummer&Suchwort=2902
- ÖKO-RECHERCHE, 2005: Emissionen und Emissionsprognose von H-FKW, FKW und SF6 in Deutschland - Aktueller Stand und Entwicklung eines Systems zur jährlichen Ermittlung (Emissionsdaten bis 2003 und Emissionsprognosen für die Jahre 2010 und 2020), Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 202 41 356. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennnummer&Suchwort=3000
- ÖKO-RECHERCHE, 2007: Daten von H-FKW, FKW und SF6 für die nationale Emissionsberichterstattung gemäß Klimarahmenkonvention für die Berichtsjahre 2004 und 2005 (F-Gas-Emissionen 2004/2005 und Unsicherheitsbestimmung im ZSE), Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 205 41 217/01. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennnummer&Suchwort=3439
- ÖKO-RECHERCHE, 2009: Öko-Recherche - Büro für Umweltforschung und -beratung GmbH, Dr. Winfried Schwarz: SF₆ und NF₃ in der deutschen Photovoltaik-Industrie - Inventarverbesserung 2008 – Verbesserung und Ergänzung der Daten für die nationale Emissionsberichterstattung gemäß Klimarahmenkonvention in der Quellgruppe Photovoltaik (2.F.8.h), Endbericht, FuE-Vorhaben FKZ 360 16 027, Frankfurt a.M., Dezember 2009.
- ÖKO-RECHERCHE, Ecofys, 2003: Establishing the Leakage Rates of Mobile Air Conditioners. Report on the EU Commission (DG Environment). B4-3040/2002/337136/MAR/C1. Frankfurt/Nürnberg.
- ORELLAS, D.L., 1982: Heat and Products of Detonation for Explosives, Lawrence Livermore National Laboratory, University of California, USA, April 5th
- OSOWSKI, S., J. NEUMANN & H. FAHLENKAMP (2004): Nutzung biogener Festbrennstoffe in Vergasungsanlagen. Chemie Ingenieur Technik, 76, No. 7
- PISTORIUS, T.; ZELL, J.; HARTEBRODT, C. (2006): Untersuchungen zur Rolle des Waldes und der Forstwirtschaft im Kohlenstoffhaushalt des Landes Baden-Württemberg; Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, Institut für Forstökonomie, Technischer Bericht; 224 S.
- POST, W.M. & K.C. KWON (2000): Soil carbon sequestration and land-use change: processes and potential. Global Change Biology, 6, 317 – 327
- PREISEGGER, 1999: Solvay Fluor und Derivate GmbH: Automotive Air Conditioning Impact of Refrigerant on Global Warming, in: Joint IPCC/TEAP Expert Meeting on Options for the Limitation of Emissions of HFCs and PFCs, Petten, 26-28 May 1999.
- PROGNOS, 2000: Anwendung des IPCC-Referenzverfahrens zur Ermittlung der verbrennungsbedingten CO₂-Emissionen in Deutschland, Forschungsprojekt des UBA, FKZ 29744850, 2000

- RENTZ et al, 2002: Rentz, Otto; Karl, Ute; Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010, Bericht zum Forschungsprojekt des Umweltbundesamtes unter FKZ 299 43 142, durchgeführt vom DFIU (Universität Karlsruhe, Deutsch-Französisches Institut für Umweltforschung)
- RENTZ et al, 2002: Rentz, Otto; Karl, Ute; Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010, Bericht zum Forschungsprojekt des Umweltbundesamtes unter FKZ 299 43 142, durchgeführt vom DFIU (Universität Karlsruhe, Deutsch-Französisches Institut für Umweltforschung)
- RENTZ et al. 2002b: O. Rentz, K. Gütling und U. Karl 2002: Erarbeitung der Grundlagen für das BVT-Merkblatt Großfeuerungsanlagen im Rahmen des Informationsaustausches nach Art. 16(2) IVU-Richtlinie, Forschungsbericht 200 46 317, Gutachten im Auftrag des Umweltbundesamtes.
- RETTENBERGER et al, 1997: RETTENBERGER, STEGMANN: Neue Aspekte der Deponiegasnutzung. Trierer Berichte zur Abfallwirtschaft Band 11. Economica-Verlag Bonn 1997. u.a. S. 268, 319
- RÖSEMANN et al. 2011: Rösemann C, Haenel H-D, Poddey E, Dämmgen U, Döhler H, Eurich-Menden B, Laubach P, Dieterle M, Osterburg B: Calculation of gaseous and particulate emissions from German agriculture 1990 – 2009. Methods and data. Landbauforschung - vTI Agriculture and Forestry Research (in preparation).
- ROSS, C.W. & K.A. HUGHES 1985: Maize/oates forage rotation under three cultivation systems, 1978-83. 2. Soil properties. New Zealand Journal of Agricultural Research, 28, 209-219
- RUHR-STICKSTOFF Aktiengesellschaft (1985): Faustzahlen für Landwirtschaft und Gartenbau. 10. überarbeitete Auflage, 584. S. Verlagsunion Agrar, Münster-Hiltrup, München, Frankfurt a.M., Wien, Bern
- SACHS, L. 1984: Angewandte Statistik. Bd. 6. Aufl., Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.
- SCHÖN, WALZ, et al. 1993: Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland : Emissionsbilanz, Identifikation von Forschungs- und Handlungsbedarf sowie Erarbeitung von Handlungsempfehlungen, ISBN 3-503-03495-1
- SCHWITZGEBEL et al. 2007: Schwitzgebel, F., Dunger, K., Stümer, W. (2007): Waldinventurstudie 2008 - Informationsquelle zur Kohlenstoff-Einbindung. AFZ-Der Wald 23/07.
- SENDER et al, 1991: SENDER F, SCHERZ H.: Der Kleine "Souci-Fachmann-Kraut", Lebensmitteltabelle für die Praxis, 2. Auflage Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart
- SIEGL et al., 2002: R-134a Emissions from Vehicles, ENVIRON. SCI & TECHNOL., VOL. 36, 561-566.
- SKEMSTAD, J.O., V.R. CATCHPOOLE & R.P. LE FEUVRE (1994): Carbon dynamics in Vertisols under several crops as assessed by natural abundance ¹³C. Australian Journal of Soil Research, 32, 311-321

- SLL. 2005: Sächsische Landesanstalt für Landwirtschaft (Hrsg.) (2005) Infodienst 02/2005 für Beratung und Schule der Sächsischen Agrarverwaltung http://www.smul.sachsen.de/lfl/publikationen/download/1256_1.pdf
- STATISTIK DER KOHLENWIRTSCHAFT e.V 2010: Statistik der Kohlenwirtschaft, „Herstellung von Braunkohlenbriketts, Braunkohlenkoks, Staub-, Trocken- und Wirbelschichtkohle nach Revieren“, www.kohlenstatistik.de.
- STATISTISCHES BUNDESAMT, 1989: CORINE Land Cover - Nomenklatur der Bodenbedeckungen. URL: http://www.destatis.de/stbis/oc_1110/f20/d/nomenkla.htm
- STATISTISCHES BUNDESAMT, 1991-2005: Statistisches Bundesamt: Fachserien (Zeitschrift), siehe Einzelquellen
- STATISTISCHES BUNDESAMT, 1992: Statistisches Bundesamt, Statistisches Jahrbuch 1992 für die Bundesrepublik Deutschland, Tab. 26.2.1 An Abfallbeseitigungsanlagen angelieferte Abfallmengen nach Art der Anlagen, Tab. 26.2.2 An Abfallbeseitigungsanlagen angelieferte Abfallmengen nach Abfallarten
- STATISTISCHES BUNDESAMT, 2002c: Statistisches Bundesamt, Klassifikation der Wirtschaftszweige, Ausgabe 1993 (WZ93), Wiesbaden 2002.
- STATISTISCHES BUNDESAMT, 2003, Klassifikation der Wirtschaftszweige mit Erläuterungen 2003, Wiesbaden
- STATISTISCHES BUNDESAMT 2009a: Statistisches Bundesamt, Statistik 066 „Monatsberichte über die Elektrizitätsversorgung / Dezember 2006“ Tab. 3.2 und Tab. 5b.
- STATISTISCHES BUNDESAMT, 2009b: Statistisches Bundesamt, Statistik 060: Auswertungen des Statistischen Bundesamtes der Bundesrepublik Deutschland „Energieverwendung der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden“
- STATISTISCHES BUNDESAMT, 2009c: Statistisches Bundesamt, Statistik 067: Auswertungen des Statistischen Bundesamtes der Bundesrepublik Deutschland „Stromerzeugungsanlagen der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden“
- STATISTISCHES BUNDESAMT 2009d: Statistisches Bundesamt, „Stromerzeugungsanlagen der Betriebe im Bergbau und Verarbeitenden Gewerbe“.
- STATISTISCHES BUNDESAMT, 2010: Statistisches Jahrbuch 2010, erschienen im September 2010-10-29 unter <http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Querschnittsveroeffentlichungen/Jahrbuch>
- STATISTISCHES BUNDESAMT, 2010a: Außenhandelsstatistik, Sonderauswertung Nr. 28362000 für das UBA, Ausfuhr und Einfuhr nach Gewicht entsprechend Güterverzeichnis 2009 Dinatriumcarbonat (Soda) 2013 43 100, Wiesbaden.
- STATISTISCHES BUNDESAMT, Fachserie 3 Reihe 3, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 4: Viehbestand und tierische Erzeugung

- STATISTISCHES BUNDESAMT, FACHSERIE 3, Reihe 3.2.2, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 3.2.2: Erhebung der Weinerzeugung - Wein- und Mostmengen nach Qualitätsstufen und Weinmostart (Weißmost/Rotmost)
- STATISTISCHES BUNDESAMT, Fachserie 3 Reihe 4, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 4: Viehbestand und tierische Erzeugung.
- STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 3.1, Jg. ab 1991: Statistisches Bundesamt, Fachserie 4, Reihe 3.1: Produzierendes Gewerbe - Produktion im produzierenden Gewerbe, Wiesbaden
- STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 4.1.1, Jg. ab 1991-2003: Statistisches Bundesamt, Fachserie 4, Reihe 4.1.1: Erhebung über die Energieverwendung der Betriebe des verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden, Wiesbaden
- STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 6.4, Jg. ab 1991: Statistisches Bundesamt, Fachserie 4, Reihe 6.4: Stromerzeugungsanlagen der Betriebe im Bergbau und im verarbeitenden Gewerbe, Wiesbaden.
- STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 8.1, versch. Jahrgänge: Statistisches Bundesamt; Fachserie 4, Reihe 8.1; Eisen und Stahl, Poeschel-Verlag
- STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 8.2, Jg. ab 1990: Statistisches Bundesamt, Fachserie 4, Reihe 8.2: Produzierendes Gewerbe, Düngemittelversorgung, Wiesbaden.
- STATISTISCHES BUNDESAMT, Fachserie 8 Reihe 4, Jg. ab 1991: Statistisches Bundesamt, Fachserie 8, Reihe 4: Binnenschifffahrt (für die Jahre 1990-2003), Wiesbaden.
- STATISTISCHES BUNDESAMT, Fachserie 19 Reihe 1, Jg ab 1990: Statistisches Bundesamt, Fachserie 19, Reihe 1: Umwelt, Abfallentsorgung.
- STATISTISCHES BUNDESAMT, Fachserie 19, Reihe 2.1, 2009: Statistisches Bundesamt, Fachserie 19, Reihe 2.1: Öffentliche Wasserversorgung und Abwasserbeseitigung, Klärschlamm (für die Jahre 1991, 1995, 1998, 2001, 2004, 2007), Wiesbaden
- STATISTISCHES BUNDESAMT, BGS-Bögen unveröffentlicht (Brennstoff-, Gas- und Stromwirtschaft der Hochofen-, Stahl- und Walzwerke sowie Schmiede-, Press- und Hammerwerke einschließlich der örtlich verbundenen sonstigen Betriebe (ohne eigene Kokerei))- Zusammenfassung der Erfassungsbögen der Eisen- und Stahl-Statistik (FS 4 Reihe 8.1)
- STEHFEST E, BOUWMAN L, 2006: N₂O und NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global emissions. Nutr. Cyl. Agroecosyst. 74, 207-228
- STRAUSS, Karl 1998: Kraftwerkstechnik zur Nutzung fossiler, regenerativer und nuklearer Energiequellen. 4. Auflage. Springer-Verlag.
- STRUSCHKA, 2008: Struschka, Dr. M., Kilgus, D., Springmann, M.; Baumbach, Prof.Dr. Günter: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung; UBA-Forschungsbericht 205 42 322; Dessau, 2008.

- TA LUFT, 1986: Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz, TA Luft - Technische Anleitung zur Reinhaltung der Luft, vom 27. Februar 1986, Gemeinsames Ministerialblatt S. 95, ber. S. 202)
- TA LUFT, 2002: Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz, TA Luft - Technische Anleitung zur Reinhaltung der Luft, vom 24. Juli 2002, Gemeinsames Ministerialblatt (GMBI). Nr. 25 - 29 vom 30.7. 2002 S. 511ff.
- TIESSEN, H., J.W.B. STEWART & J.R. BETTANY (1982): Cultivation effects on the amounts and concentration of carbon, nitrogen, and phosphorous in grassland soils. *Agronomy Journal*, 74, 831-835
- UBA, 1983: Greiner, B., Barghoorn, M. Dobberstein, J., Eder, G., Fuchs, J., Gössele, P.: Chemisch-physikalische Analyse von Hausmüll. Forschungsbericht 83-033 im Auftrag des Umweltbundesamtes, Berlin.
- UBA, 1986: Barghoorn, M., Gössele, P., Kaworski, W.: Bundesweite Hausmüllanalyse 1983-85, Forschungsbericht 10303508 im Auftrag des Umweltbundesamtes, Berlin.
- UBA, 1989b: Luftreinhaltung '88. Tendenzen - Probleme - Lösungen. Materialien zum Vierten Immissionsschutzbericht der Bundesregierung an den Deutschen Bundestag (Drucksache 11/2714) nach Paragraph 61 Bundes-Immissionsschutzgesetz Körperschaft, erschienen Berlin Schmidt, E.
- UBA, 1993: Umweltbundesamt: UBA-Text 9/93, Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland. Auftragnehmer: Schön, M. et al. Fhg-ISI
- UBA, 2000a: UBA-Text 14/00: Pfeiffer, Frank / Struschka, Michael / Baumbach, Günter: Ermittlung der mittleren Emissionsfaktoren zur Darstellung der Emissionsentwicklung aus Feuerungsanlagen im Bereich der Haushalte und Kleinverbraucher, Institut für Verfahrenstechnik und Dampfkesselwesen, Universität Stuttgart, Herausgeber: Umweltbundesamt, FKZ 299 42 245 / 02, Berlin
- UBA, 2001: German Notes on BAT for the production of Large Volume Solid Inorganic Chemicals – Soda. URL: www.bvt.umweltbundesamt.de/archiv/sodad.pdf english: www.bvt.umweltbundesamt.de/archiv-e/sodae.pdf)
- UBA, 2001a: Umweltbundesamt: UBA-Text 17/01: Maßnahmen zur verursacherbezogenen Schadstoffreduzierung des zivilen Flugverkehrs
- UBA, 2003a: Projekthandbuch Decor, Umweltbundesamt, Förderkennzeichen IT 20, in Bearbeitung
- UBA, 2004: IZT, KPMG, DFIU: Arbeitsergebnisse aus dem F+E-Vorhaben 202 42 266 „Bestimmung und Einführung von Methoden zur Qualitätssicherung und Qualitätskontrolle für die deutschen Inventare der Treibhausgasemissionen entsprechend den Vorgaben der Klimarahmenkonvention (KRK) und der Anforderung der ECE-Luftreinhaltekonvention“ (unveröffentlicht)
- UBA, 2004b: Dr. R. Joas; A. Potrykus; R. Schott; S. Wenzel: VOC-Minderungspotenzial beim Transport und Umschlag von Mineralölprodukten mittels Kesselwagen, FKZ 202 44 372, UBA-Texte 12/2004, Dessau.
URL: <http://www.umweltdaten.de/publikationen/fpdf-l/2637.pdf>

- UBA 2005b, FKZ 20442203/02: Endbericht zum Forschungsprojekt „Einsatz von Sekundärbrennstoffen“
- UBA 2005c, FKZ 20541115: unveröffentlichter Zwischenbericht zum Forschungsprojekt „Bereitstellung der Energiedaten für stationäre Feuerungsanlagen zur Erfüllung der Berichtspflichten im Rahmen des Nationalen Treibhausgasinventars (NIR 2006) und des Berichtes zur Festlegung der zugewiesenen Mengen nach Kyoto-Protokoll“
- UBA, 2006: Umweltbundesamt: UBA-Text 29/06, Lechtenböhmer, Nanning, Buttermann, Hillebrand: Bilanzierung der Gewinnung und Verwendung von Kalkstein und Ausweisung der CO₂-Emissionen, Forschungsbericht FKZ 20541217/02, Dessau 2006
- UBA, 2007: Dr. Matthias Kühle-Weidemeier, Wasteconsult International: Endbericht des UFOPlan-Projekts „Anlagen zur mechanisch-biologischen Restabfallbehandlung, FKZ 206 33 301. Juni 2007
- UBA 2007b: Umweltbundesamt: Qualitätssystem Emissionsinventare. Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU-Entscheidung 280/2004/EG, Dessau. Stand 05.06.2007, unveröffentlicht.
- UBA, 2009: Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen 2009, Nationaler Inventarbericht zum Deutschen Treibhausgasinventar 1990-2007, Umweltbundesamt 2009
- UBA, 2010: Ableitung der Kalksteinbilanz aus den statistischen Daten der BGR für Zwecke der Emissionsberichterstattung nach Klimarahmenkonvention und Kyoto Protokoll (Kategorie CRF 2.A.3), Publikationsnummer 4033, direkt unter <http://www.uba.de/uba-info-medien/4033.html>
- UMEG 2004: Umweltmessungen, Umwelterhebungen und Gerätesicherheit 2004: Emissionsfaktoren-Handbuch, Emissionserklärung 2004 Baden-Württemberg
- UNFCCC, 1998: Kyoto Protocol to the United Nations Framework Convention on Climate Change, United Nations 1998
- UNFCCC, 2005: Germany. Report of the individual review of the greenhouse gas inventory submitted in the year 2004. FCCC/WEB/IRI/2994/DEU, dd. January 17, 2005. http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/2004_irr_in-country_review_germany.pdf
- UNFCCC, 2009: United Nations Framework Convention on Climate Change: National Inventory Submissions 2009
URL: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/4303.php
- UU STS, 2007: Utrecht University (UU), Copernicus Institute Department of Science, Technology, and Society (STS): Estimating CO₂ Emissions from the Non- Energy Use of Fossil Fuels in Germany - Methodenaktualisierung für die Emissionsberechnung 2003, FKZ 203 41 253/02.

- VDD 2009: Datenübermittlung des Verbandes, Dokument in der Inventarbeschreibung als „2010_2.A.5_Bitumen_AREF_Zeitreihen_und_Unsicherheiten(offen).xls“, Dessau-Roßlau 2009
- VDD 2010: Datenübermittlung des Verbandes, Dokument in der Inventarbeschreibung als „Bitumen_AREF_Zeitreihen_und_Unsicherheiten_aktuell.xls“, Dessau-Roßlau 2010
- VDP, versch. JG: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn, verschiedene Jahrgänge seit 1990
- VDP, 2004: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn
- VDZ, 2010 (Verein Deutscher Zementwerke e.V.): Zement – Produktionsdaten der deutschen Zementindustrie; per E-Mail an das UBA übermittelt.
- VOGT, K.A.; VOGT, D.J.; PALMIOTTO, P.A.; OON, P.; OHARA, J.; ASBJORNSSEN, H. (1996): Review of root dynamics in forest ecosystems grouped by climate, climatic forest type and species. Plant and Soil, Vol. 187 Nr.2, pp. 159-219
- VOLK, F., 1997: Recherches sur les Fumees Produits par la Detonation de divers Explosifs, Explosifs
- VOLZ et al. 2008: Volz, H.-J., Schobel, S., Wellbrock, N. & Hilbrig, L. (2008): Qualitätsmanagement bei der Bodenzustandserhebung im Wald (BZE II) auf Bundesebene. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Berlin
- VORNEY, R.P., J.A. VAN VEEN & E.A. PAUL (1981): Organic C dynamics in grassland soils. 2. Model validation and simulation of the long-term effects of cultivation and rainfall erosion. Canadian Journal of Soil Science, 61, 211-224
- vTI-AK, 2009: Konzept zur Erstellung von Emissions-Inventaren und Kohlenstoff-Inventaren im nachgeordneten Bereich des BMELV - Stand 10.07.2009 -, Johann Heinrich von Thünen-Institut, Institut für Agrarrelevante Klimaforschung, unveröffentlicht.
- WASTECONSULT INTERNATIONAL, 2009: Methanemissionen aus passiv entgasten Deponien und der Ablagerung von mechanisch-biologisch vorbehandelten Abfällen, FKZ: 360 16 015, Dezember 2009
- WEG, 2000: Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V.: ERDGAS - ERDÖL. Entstehung, Suche, Förderung. Hannover. URL: <http://www.erdoel-erdgas.de/Publikationen-68a.html>
- WEG, 2008: WEG Wirtschaftsverband Erdöl und Erdgasgewinnung e.V.: Jahresbericht 2008, Zahlen und Fakten. Hannover. URL: <http://www.erdoel-erdgas.de/Publikationen-68a.html>
- WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 S. URL: http://www.erdoel-erdgas.de/Erdgas_Erd%F6l___Entstehung___Suche___F%F6rderung-134-1-68b.html
- WEG, 2008b: WEG Bericht zur Schwefelgewinnung im Inland, URL: <http://www.erdoel-erdgas.de/article/articleview/13/1/59/>
- WEG (2010): Jahresbericht des Wirtschaftsverbandes Erdöl- und Erdgasgewinnung e.V., WEG, 2010

- WEILBACHER, 1987: Ausgasung von Zellgasen, interner Laborbericht vom 17.08.87 (überreicht von der BASF AG, Ludwigshafen).
- WEINGARTEN, P., 1995: Das „Regionalisierte Agrar- und Umweltinformationssystem für die Bundesrepublik Deutschland“ (RAUMIS). Ber Landwirtschaft 73, 272-302
- WEISS, SCHIELER, SCHADAUER, RADUNSKY, ENGLISCH, 2000: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Umweltbundesamt GmbH, Wien.
- WELLBROCK et al. 2006: Wellbrock, N.; Aydin, C. - T.; Block, J.; Bussian, B.; Deckert, M.; Diekmann, O.; Evers, J.; Fetzer, K. D.; Gauer, J.; Gehrmann, J.; Kölling, C.; König, N.; Liesebach, M.; Martin, J.; Meiwes, K. J.; Milbert, G.; Raben, G.; Riek, W.; Schäffer, W.; Schwerhoff, J.; Ullrich, T.; Utermann, J.; Volz, H. - A.; Weigel, A.; Wolff, B. (2006): Bodenzustandserhebung im Wald (BZE II) Arbeitsanleitung für die Außenaufnahmen. Hrsg. BMELV. Berlin. pp. 413.
- WIRTH, C.; SCHULZE, E.-D.; SCHWALBE, G.; TOMCZYK, S.; WEBER, G.; WELLER, E. (2004): Dynamik der Kohlenstoffvorräte in den Wäldern Thüringens. Thüringer Landesanstalt für Wald, Jagd und Fischerei, Jena, 308 S.
- WOLFF & RIEK 1996: Wolff, B.; Riek, W. (1996): Deutscher Waldbodenbericht 1996 - Ergebnisse der bundesweiten Bodenzustandserhebung in Wald (BZE) 1987 - 1993. Hrsg.: Bundesministerium für Ernährung, Landwirtschaft und Forsten, Bonn, Bd. 1 u. 2.
- ZIESING et al, 2003: Ziesing, Hans-Joachim (DIW), Felix Christian Matthes, (Öko-Institut), Franz Wittke (AGEB), Heike Leonhardt (UBA) „Harmonisierung der Energiedaten zur CO₂-Berechnung“, Endbericht zum EUROSTAT-Vorhaben des Umweltbundesamtes, 24.04.2003, aktualisiert um die „Energiebilanz 1999“ vom 20.09.2003
- ZIESING 2009: Ziesing, Hans Joachim: CO₂-Emissionen in Deutschland 2008:Im Abschwung. In: Energiewirtschaftliche Tagesfragen Jg. 59, Heft 4, Mai 2009