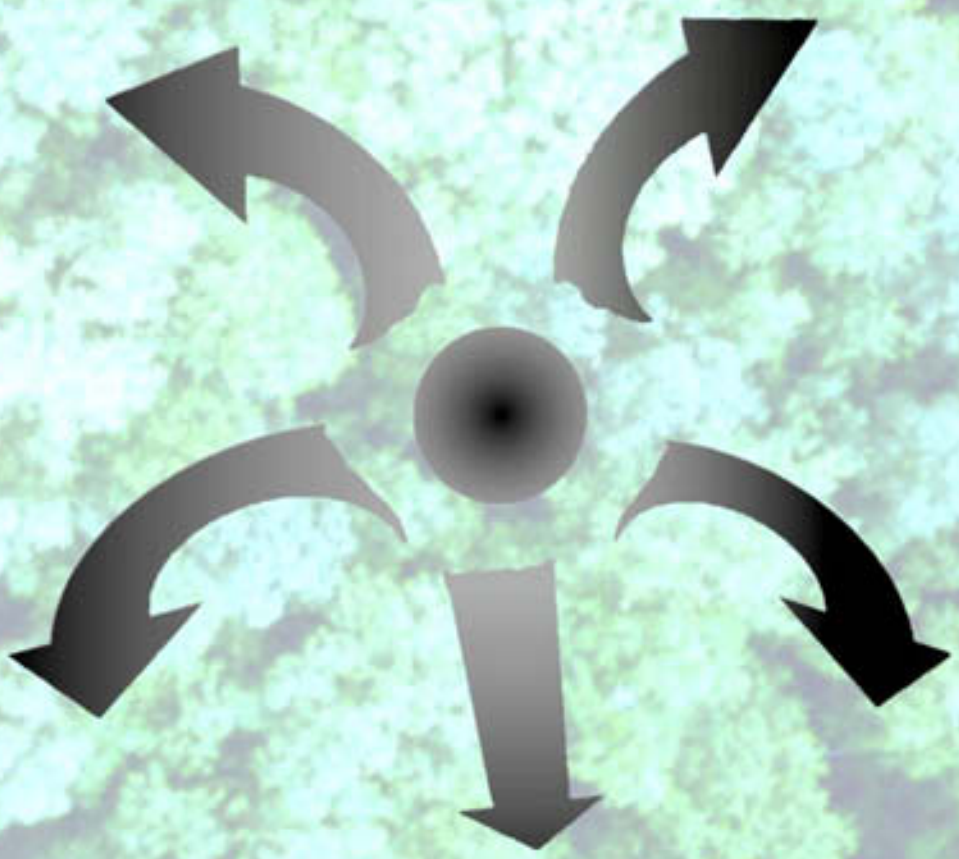
Manual

Environmental Effects of Businesses and Organizations

Their assessment and evaluation for environmental management



Umwelt Bundes Amt
für Mensch und Umwelt

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Another manual on environmental management?

Let's suppose ...
Your balance sheet shows that energy consumption is down, and the emissions of dust particles have declined as well during the past few years. On the other hand, you find that considerable quantities of water are still being consumed, despite your efforts to reduce them. Should your company now focus on the water problem?
Maybe the environment is capable of tolerating water use better than the present concentrations of dust particles in the area, which are still relatively high because of the emissions of many other industrial plants. Your reduction of energy consumption is a great success. However, the outsourcing of some of your production last year has increased the volume of transportation. Maybe your company's contribution to the greenhouse effect has not changed as much as you thought. What do you do?

What is the most effective use of a budget for environmental protection?

To estimate which steps will be the most effective, we must first determine which areas of the environment are most strongly impacted by an enterprise. In other words: Money and time are best spent wherever any improvements of the environmental situation will be most noticeable.
Therefore, your organization's approach towards environmental problem-solving needs to change: The focus should no longer be on the emissions themselves, but on their effects – the ailing forests, and ozone degradation in the stratosphere – i.e. the approach needs to reflect the environmental effects and the problems they create. Appropriate measures are decided upon by tracing the effects to their causes.

Good intentions – but are they an illusion?

We think that you should be able to advance toward this ideal without unreasonable effort. This manual, which has been designed in collaboration with five medium-sized companies, is designed to help you attain the goal.
It will require a small effort, of course. The assessment of your enterprise's environmental effects will take time. But the main effort consists in the compilation of the data for the input-output balance, a largely standard procedure in today's environmental management. Besides, it is not really necessary to deal with all environmental problem areas at once. The method will enable you to make the necessary selections.

Why go through the trouble?

It will not only help the environment – your enterprise will profit as well.
The organization's image will improve: The public usually cares little about the quantities of any particular substance emitted by a enterprise. But it may ask about the environmental problems it creates, and about the enterprise's contribution to pollution abatement, which will become apparent if the it publishes the environmental effects that result from its activities. This will not only protect the enterprise from unreasonable demands, the public will also acknowledge that it focuses its efforts on the critical issues.
Economic efficiency will improve: It will become possible to use the budget available for environmental protection measures more efficiently. Low-cost alternatives might become apparent.

In writing this manual, we have aimed at providing businesses and organizations with a simple and easily understandable tool to assess and evaluate the environmental consequences of their activities – an ambitious task, but very much worthwhile. We thank everyone involved in the elaboration of this manual, and we hope that it will be widely used. Any further suggestions and comments are most welcome.

The editors

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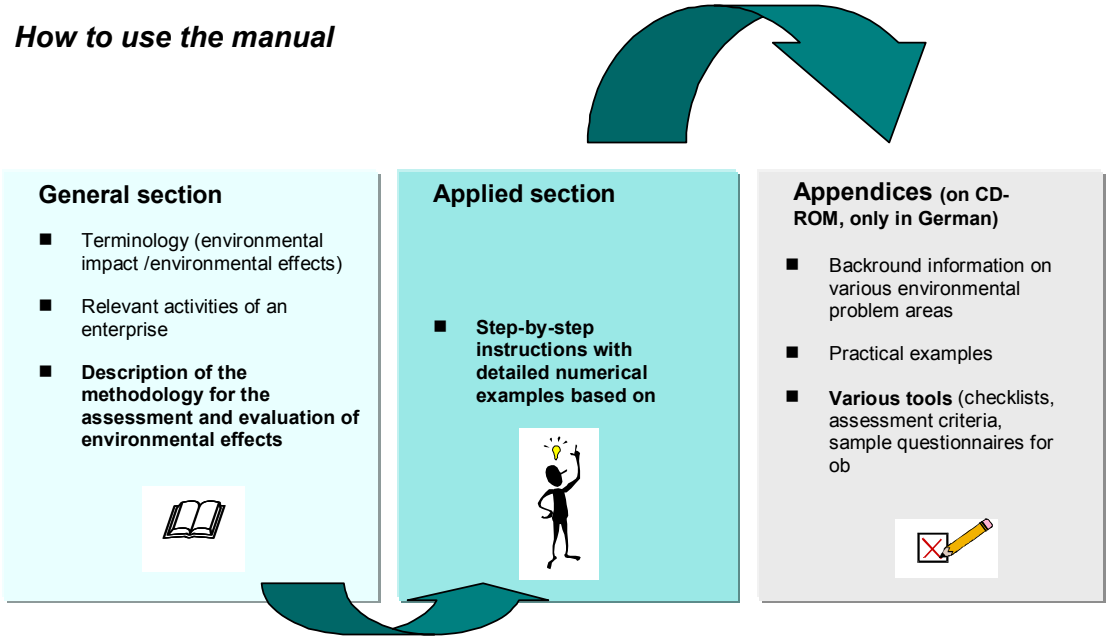
How to use the manual



The manual consists of three main sections:

- Section 1: General section
- Section 2: Applied section
- Section 3: Appendices (CD-ROM) (only in German)

Each of these parts is important: The general section introduces the topic (Chapter 1). This part of the manual is particularly written for readers lacking experience in the field of environmental protection in businesses and organizations. Terms such as "environmental impacts" and "environmental effects" are defined and explained.

Furthermore, the general section contains a description of the methodology for assessment and evaluation of the environmental effects of an enterprise. Readers with experience in the field of environmental effects may therefore opt to begin immediately with Chapter 2 (Relevant environmental impacts of an industrial enterprise), and continue with the description of the methodology (Chapter 3). These two chapters explain in detail the procedures to assess and evaluate environmental effects.

Even readers with detailed background knowledge will profit from reading Chapters 2 and 3, because they help to clarify statements made further on in the manual. Having gained the basic information provided in Chapters 1 to 3, an enterprise can venture into the applied section (Chapter 4, step-by-step instructions) and apply the methodology to data from its own enterprise.

Closely related to Chapter 4 are the appendices, which provide a framework for implementation of the manual (various tools such as checklists, data assessment and evaluation sheets, sample worksheets, questionnaires to obtain environmental data from government agencies, and last but not least, a list of information sources and addresses).

Important terms that are explained further in the text or that have a particular significance are emphasized in color. Arrows at the beginning of a word indicate that it may be looked up in the glossary. Square brackets denote tools in the appendix or indicate other parts of the manual.

1 Overview

The terms environmental impacts and environmental effects are of central importance in the manual. However, since these and similar terms may have various different meanings among experts, they will first be explained and defined.

1.1 Environmental impacts

→ Environmental impacts are generally understood to encompass all anthropogenic impacts (of the economy, or the population) that burden the environment. The principal environmental impacts include:

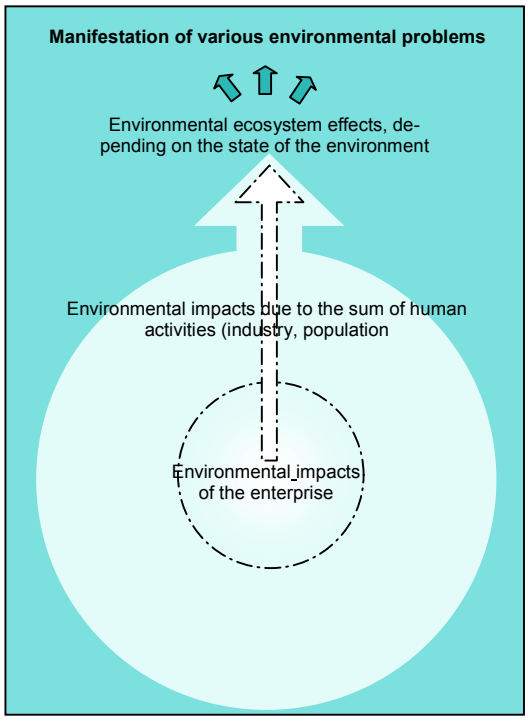
- *Emissions of matter* (e.g. waste air emissions, wastewater discharges etc.),
- *Emissions of noise*,
- *Consumption and utilization of resources* (fossil fuels, raw materials, water),
- *Use of land*, and
- *Visual impacts* due to the prominence of buildings

Environmental impacts may affect the environment at a distance from their source. Noise emissions, for instance, generally have a very limited sphere of impact, i.e. they act locally, in the vicinity of the emitting facility. Atmospheric emissions, on the other hand, may be carried beyond the vicinity of the source, and affect the region or larger geographical areas, sometimes attaining global significance.

1.2 Environmental effects

Environmental effects in the → ecosystem represent the environment's reaction to the impacts described above (→ Appendix 1: Background information on environmental problems).

Fig. 1.1: Relationship between environmental impacts and environmental effects



Depending on the type and the characteristics of the environmental impacts, environmental effects may

- occur on a *short-term*, *medium- term*, or *long-term* scale,
- be *permanent*, or *temporary*,
- be *reversible*, or *irreversible*,
- have *cumulative* effects,
- act *synergetically* (reinforcing each other), or *antagonistically*,
- have *positive*, or *negative* effects (i.e. improve, or damage the ecosystem).

The so-called primary environmental effects, which represent an ecosystem's first reaction to environmental impacts, may entail a series of consequential

impacts. An example of a primary effect is the acidification of the soil due to inputs of air-borne acid compounds. Consequential impacts of soil acidification may include damage to plants and to other organisms associated with the soil.

The possible negative effects of the environmental impacts acting upon an ecosystem depend on the overall magnitude of the impacts in the reference area, as well as on the state of the environment. Ecosystems are able to compensate stress to a certain extent. Processes which damage individual components of the environment only emerge after certain tolerance limits are exceeded ("limits of ecological carrying capacity"). Similarly, humans react to stress with an impairment of their well-being and health.

The tolerance limits of an ecosystem depend on its sensitivity. Bogs, for instance, are highly sensitive ecosystems. The sensitivity of the population to environmental impacts also varies. Sensitive sectors of the population include, for instance, infants, the elderly, and the sick.

Assessments and evaluations of environmental effects are often analyzed in the context of environmental problem areas, because this approach makes the problem more manageable. Environmental problem areas are usually identified by the primary effect in the ecosystem (e.g., acidification of the soil) [→ Appendix 1: Background information on environmental problem areas].

2 Assessment of the environmental impacts of an enterprise - scoping

To determine the environmental effects of a business or an organization, we first need to identify the environmental impacts that result from its activities. This topic will be dealt with below in Sections 2.1 and 2.2 (→ Chapter 4: Practical step-by-step instructions, phase I).

2.1 Relevant environmental impacts

All enterprises affect the environment by their activities, products, and services. In this regard, we can discriminate between direct and indirect environmental impacts of an organization.

- Direct environmental impacts

The direct environmental impacts of a business or an organization are defined as the impacts resulting from the sum of its activities at a given location. These include any transportation of goods and people carried out with its own vehicles. Examples of direct environmental impacts of an enterprise are:

- *Resource exploitation through the extraction of water* (by the enterprise itself)
- *Land use* for the infrastructure of the enterprise (buildings etc.)
- *Emissions of atmospheric pollutants* on site and through transportation
- *Discharge of waste water into a drainage ditch* (direct discharge)
- *Land use* due to waste disposal on the enterprise's own landfill
- *Noise emissions*

- Indirect environmental impacts

Businesses and organizations are linked to other parts of the economy by their activities. Thus, they may affect the environment indirectly through the activities of enterprises with which they interact. This is significant in the case of industrial facilities carrying out prior or subsequent production stages, as well as in utility companies. Indirect impacts may occur both within and beyond the region in which the enterprise in question is located.

Relevant services provided by → utility companies include the supply of energy and water, and the removal and treatment of wastes and waste water [→ Chapter 4, and Appendix III, Checklist no. 2]. These services result in direct environmental impacts of the utilities, and represent indirect impacts from the viewpoint of the business or organization that uses its services. Transportation activities of a utility that are due to the enterprise in question equally represent indirect environmental impacts.

Other indirect environmental impacts can result from → prior and subsequent production stages related to the production of unfinished materials, and to the subsequent life cycle of a product. Examples are the emissions and the utilization of resources due to the extraction of raw materials and the production of unfinished materials. Some products, such as washing machines and automobiles, may by their use generate environmental impacts similar to those of their manufacture. Indirect impacts can also result from additional processing or finishing, and from the disposal of the products (e.g. disposal of batteries). Transportation linked to prior and subsequent production stages creates environmental impacts as well.

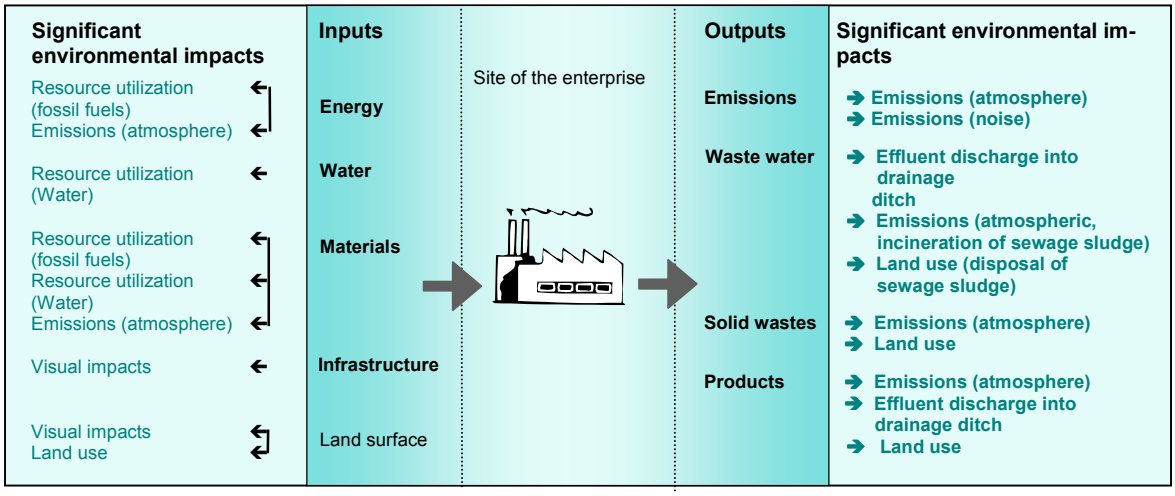
2.2 Relevant Data

The analysis of the environmental impacts of a business or an organization will first of all be based on its inputs and outputs [→ Fig. 2.1].

Some of the inputs and outputs do not themselves constitute environmental impacts. An enterprise's use of electric power, for instance, is not an environmental impact. The generation of electricity, however, creates environmental impacts, and these need to be taken into account as indirect

impacts of the enterprise. Its consumption of electricity can therefore serve to calculate resource utilization and emissions of atmospheric pollutants. This is similar in the case of the enterprise's use of materials, generation of wastes, and the goods it produces [→ Fig. 2.1].

Fig. 2.1: Industrial inputs and outputs, and resulting environmental impacts



Rather than analyzing the totality of an enterprise's inputs and outputs, it is better to make a selection of the its relevant environmental impacts to keep data collection within reasonable bounds → Checklist no. 1 and 2 in Chapter 4, and Appendix III]. The selection is based on the enterprise's local, regional and nationwide activities, and it also needs to consider its dealings with other companies.

A quantitative assessment of the environmental impacts may sometimes be impossible, due to problems of data quality or availability, or because of the nature of the impact, but a qualitative description should be possible.

An assessment must always include the principal environmental impacts caused by the enterprise's use of utility services, in addition to the direct environmental impacts of the business or organization itself.

The analysis of prior and subsequent production stages should merely consider those materials and products that are significant in quantity or that have important ecological effects. The selection of the prior and subsequent production processes to be analyzed depends on the enterprise's characteristics (range of products, economic sector etc.) and must be made on a case-by-case basis. In the food industry, for example, considerable environmental impacts result from the prior agricultural production process.

Available life cycle analyses of materials or products may be taken into consideration, but their quantitative environmental impact data need to be validated first, because they will often be inconsistent with the enterprise's own data (due to differences in assessment methods or in data quality).

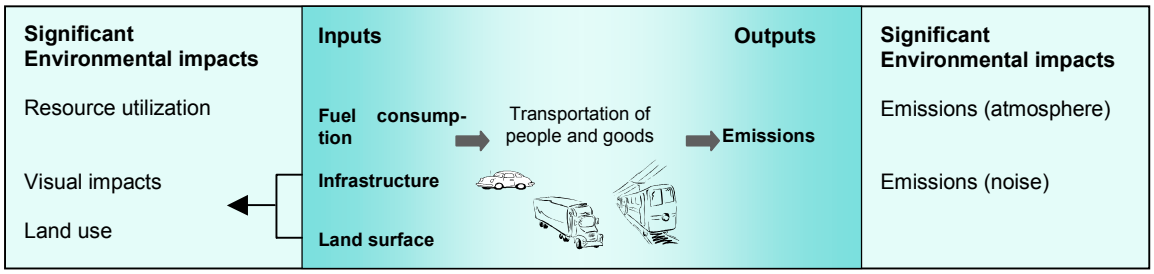
In practice, analyses will often be restricted to qualitative assessments, because of uncertainty in some of the data, and because life cycle analyses will not be available for

all of the important materials and products of an enterprise.

Any transportation of goods and people related to the activities of a business or organization will also entail environmental impacts. An overview of the principal environmental effects of the use of vehicles is shown in Fig. 2.2.

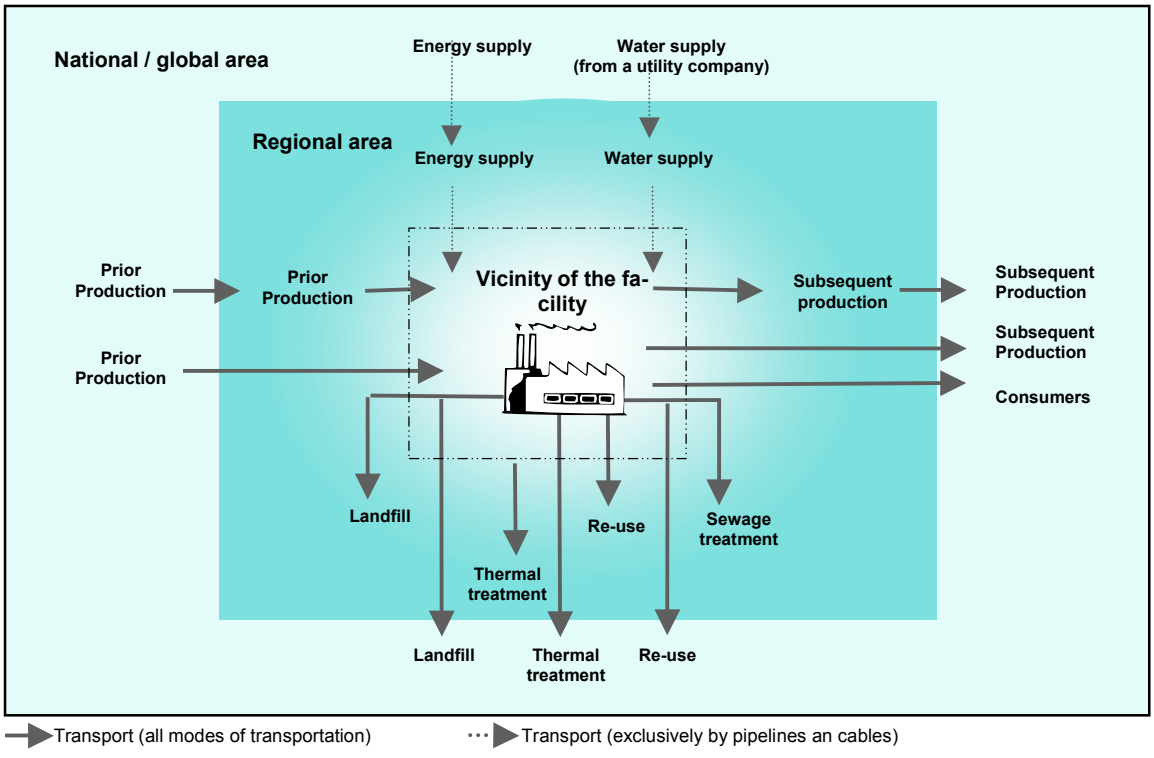
Whether or not it is justified to include transportation in the analysis depends on its volume. The most significant aspects are direct transports conducted with the enterprise's own vehicles to and from the facility in question. The environmental impacts resulting from the use of transportation services of other companies can be taken into consideration if reliable data are available.

Fig. 2.2: Environmental impacts due to transportation (use of vehicles)



The regional and national economic ties of a business or an organization that can be relevant to the analysis of its environmental impacts are illustrated in Fig. 2.3.

Fig. 2.3: The enterprise in its economic context



3 Assessment and evaluation of the environmental effects of an enterprise

To assess the effects of business or an organization on the environment, it is necessary to determine the relationship between its environmental impacts on one hand, and the state of the environment and existing environmental problems on the other. This chapter explains how to determine these relationships.

Background information on the principal environmental problems and the resulting environmental effects can be found in → Appendix I.

3.1 Analysis of the environmental effects at different geographical levels

For a complete analysis of the environmental impacts of a business or an organization, and of the resulting environmental effects, it is best to discriminate between the different geographical levels [→ Fig. 3.1 and 3.2]. This approach reflects the differences in range between different environmental impacts, and it also takes into account that an enterprise may create environmental impacts outside the region it which it is located, thus contributing to other regions' environmental problems [→ Chapter 4 and Appendix III: Data assessment sheet no. 1 with Checklists no. 1 and no. 2].

We may discriminate between the following geographical levels:

At the local level, we will consider environmental problems at the site and in the vicinity of the enterprise, which are directly related to the environmental impacts on site.

At the regional level, we will analyze the relationship between the environmental problems in the region in which the business or organization is located, and the direct and indirect environmental impacts of the enterprise.

The principal environmental impacts result from the use of the services of municipal utility companies. In addition, outsourced activities, and companies which provide unfinished materials or which are involved in subsequent processing of the enterprise's products may also have an impact on the region's environment.

At the national/global level, we analyze environmental problems of a general scope, that are of significance in many regions or globally, rather than being limited to specific aspects. A business or an organization may contribute to these problems, both by its direct environmental impacts and by the indirect environmental it causes in its region of origin and beyond.

An additional consideration of environmental problems at the national/global level makes sense for a number of reasons:

- Some of the environmental impacts caused by an enterprise will create environmental problems outside the region in which it is located (e.g. environmental impacts resulting from atmospheric emissions and distant transport of air-borne pollutants).
- On the other hand, businesses that provide unfinished materials for processing by the enterprise are often located outside the region [→ Chapter 2, Fig. 2.4]. The utilities (e.g. waste disposal companies) and outside production facilities of the enterprise need not be located in the region. Indirect environmental impacts may thus arise outside the region in which a business or organization is located.
- The fact that environmental impacts cannot always be assigned to a certain region needs to be considered as well. This is the case, e.g. with environmental impacts resulting from transportation outside the region and with the

supply of electricity via the national power grid.

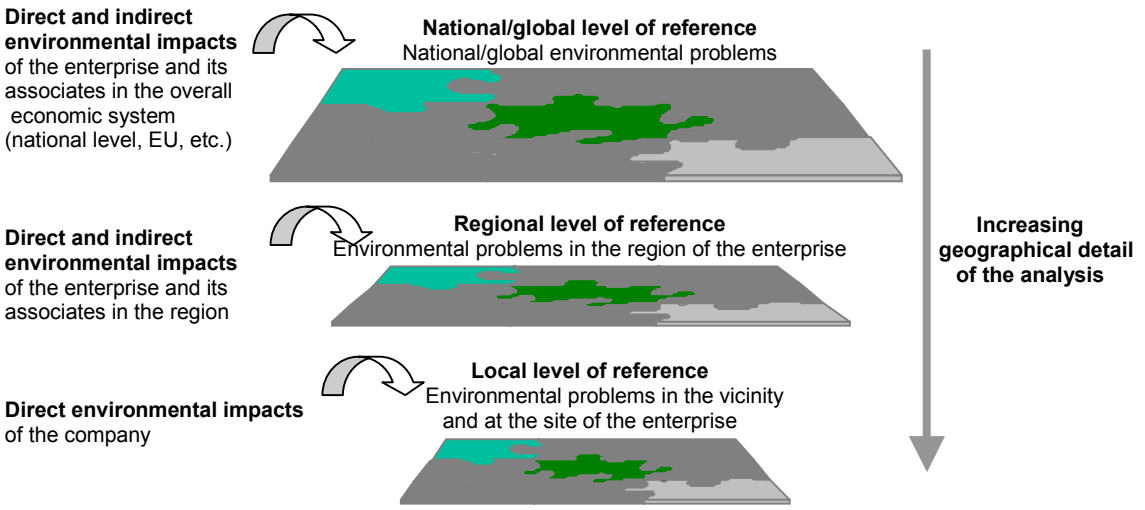
- The environmental impacts of a business or an organization may to some extent contribute to global environmental problems (e.g. CO_2 emissions contributing to global warming of the earth). Any analysis that is limited to the regional level will ignore these aspects.

For these reasons, it makes sense to consider those environmental impacts that affect other regions, or the global level – albeit at a less detailed geographical scale – in order to obtain a complete assessment of an enterprise's environmental impacts and the resulting environmental problems.

A specific issue may be analyzed at a selected geographical level if the activities of the business or organization warrant such a focus (e.g. a particular contribution of the enterprise to a regional environmental problem).

The environmental problems that may be of relevance to an enterprise are listed in Fig. 3.2 by geographical level [→ Appendix I: Background information on environmental problem areas]. If additional environmental problems are known to exist at the local and regional level, then it may become necessary to include them in the analysis as well.

Fig. 3.1: Geographical levels of reference – relevant environmental impacts and environmental problems



3.2 Contribution of an enterprise's environmental impacts to certain environmental problems

The evaluation of the environmental effects of a business or an organization requires an estimate of the magnitude of its environmental impacts, as well as their assignment to the corresponding environmental problems [→ Checklist 3: Appendix III; Chapter 4: Practical examples for the regional and national/global level]. The sum of an enterprise's environmental impacts with respect to a certain environmental problem constitutes the so-called *effect potential of the enterprise* with regard to that environmental problem.

At the local level of reference, one enterprise may often be the sole cause of a certain environmental problem, and in some cases the given problem may be attributable to a limited number of facilities whose environmental impacts are fairly well known in magnitude. In these cases it will usually be possible to demonstrate a direct relationship between cause and effect. Often it becomes possible to analyze directly the environmental effects that result from an enterprise's potential effect, without having to consider the environmental impacts [→ Appendix II: Practical examples no. 2 to no. 6 for the local level of reference]. For instance, the noise pollution in the vicinity of the site of a business or an organization may be evaluated by its immissions [→ Appendix IV: Assessment criteria].

At the regional and national/global levels of reference, on the other hand, the environmental impacts of many actors overlap. In contrast to the local level, it generally becomes impossible to establish a direct relationship between an environmental effect in the ecosystem and an individual business or organization. It is nevertheless possible to infer the environmental effects of an enterprise on the basis of its effect potential within the framework of the totality of impacts (emissions, consumption of resources) and from the state of the environment [→Appendix II: Practical examples no. 7 to no. 20 for the regional and national/global levels of reference]. An overview of the steps to follow is given in Fig. 3.4.

As shown in Fig. 3.4, at the regional and national/global levels of reference, it is first of all necessary to determine the proportion of environmental impacts contributed by the business or organization to the totality of impacts regarding a given environmental problem in the reference area (*specific contribution of the enterprise*).

Fig. 3.2: Potentially relevant environmental problems at various geographical levels

Local level of reference

(Environmental problems in the vicinity and at the site of the enterprise)

- Disturbances due to production noise
- Disturbances due to odours emitted from a production facility
- Visual disturbances due to the dominant aspects of buildings (Fragmentation of the appearance of the site or landscape, irritation of birds
- Warming of the surface in strongly sealed areas
- Existing risks (fire hazard, threats to the groundwater supply)

Regional level of reference

(Environmental problems in the region of the enterprise)

- Summer smog
- Acidification of soils and waters
- Eutrophication of soils and water
- Toxicity to humans (inhalation / food chain)
- Ecotoxicity (terrestrial, aquatic)
- Consumption of resources (water)
- Disturbances due to noise
- Fragmentation of the landscape
- Destruction of natural habitats
-

National/global level of reference

(Environmental problems of national or global importance)

- Greenhouse effect
- Ozone degradation in the stratosphere
- Consumption of resources (energy sources, raw materials)
- Summer smog
- Acidification of soil and waters
- Eutrophication of soil and waters
- Disturbances due to noise
- Fragmentation of the landscape
- Destruction of natural habitats

Table 3.1: Geographical levels of reference – relevant environmental impacts and environmental problems

Local level of reference	
Direct environmental impacts of an enterprise	**Potentially relevant environmental problems**
• Emissions of a material nature (normal operation, malfunction, accidents)	⇒ Disturbances due to odors ⇒ Fire hazard ⇒ Groundwater hazard potential
▪ Land use (grounds of the enterprise) ▪ Noise emission (site of the enterprise) ▪ Visual effects of buildings on the grounds of the enterprise	⇒ Warming of the surface ⇒ Disturbances due to noise ⇒ Visual disturbances
Regional level of reference	
Direct and indirect environmental impacts by the enterprise and its possible associates in the region	**Potentially relevant environmental problems**
▪ Emissions of a material nature	⇒ Summer smog ⇒ Acidification of soils and waters ⇒ Eutrophication of soils and waters ⇒ Toxicity to humans ⇒ Ecotoxicity
▪ Extraction of groundwater and surface water (by the enterprise itself) ▪ Land use (grounds of the enterprise)	⇒ Consumption of resources (water) ⇒ Destruction of natural habitats ⇒ Fragmentation of the landscape
▪ Noise emission (due to transportation of people and goods)	⇒ Disturbances due to noise
National/global level of reference	
Direct and indirect environmental impacts by the enterprise and its possible associates in the overall economic system (national level, EU, etc.)	**Potentially relevant environmental problems**
▪ Emission of atmospheric pollutants	⇒ Greenhouse effect ⇒ Ozone degradation in the stratosphere ⇒ Summer smog ⇒ Acidification of soils and waters ⇒ Eutrophication of soils and waters
▪ Consumption of resources (energy sources, raw materials)	⇒ Consumption of resources
▪ Land use (grounds of the enterprise)	⇒ Destruction of natural habitats ⇒ Fragmentation of the landscape
▪ Noise emission (due to transportation of people and goods)	⇒ Disturbances due to noise

The enterprise's specific contribution to an individual environmental problem area depends on the relation between its effect potential and the effect potential in the reference area:

Fig. 3.3: Computation of the specific contribution of an enterprise

Specific contribution of an enterprise:

$$\frac{\text{Effect potential of the enterprise}}{\text{Effect potential in the reference area}}$$

The specific contribution of a business or organization must be calculated separately for each environmental problem. A comparison of the various specific contributions of the enterprise makes it possible to identify those effect potentials and corresponding environmental problem areas that are significant in its particular case [→Chapter 3.4: Step 3a].

The procedure to follow when determining the contribution of the environmental impacts of a business or an organization to certain environmental problems is detailed below.

Step 1a: Determination of the effect potential of an enterprise

- **Assignment of the environmental impacts of an enterprise to environmental problems**

In this computation step, the environmental impacts of a business or an organization are assigned to the corresponding environmental problem areas. To this end, the environmental problems listed in Fig. 3.2, and possibly additional environmental problems of relevance, have to be considered at the appropriate level of reference [→Table 3.1; Chapter 4 and Appendix III: Checklist 3].

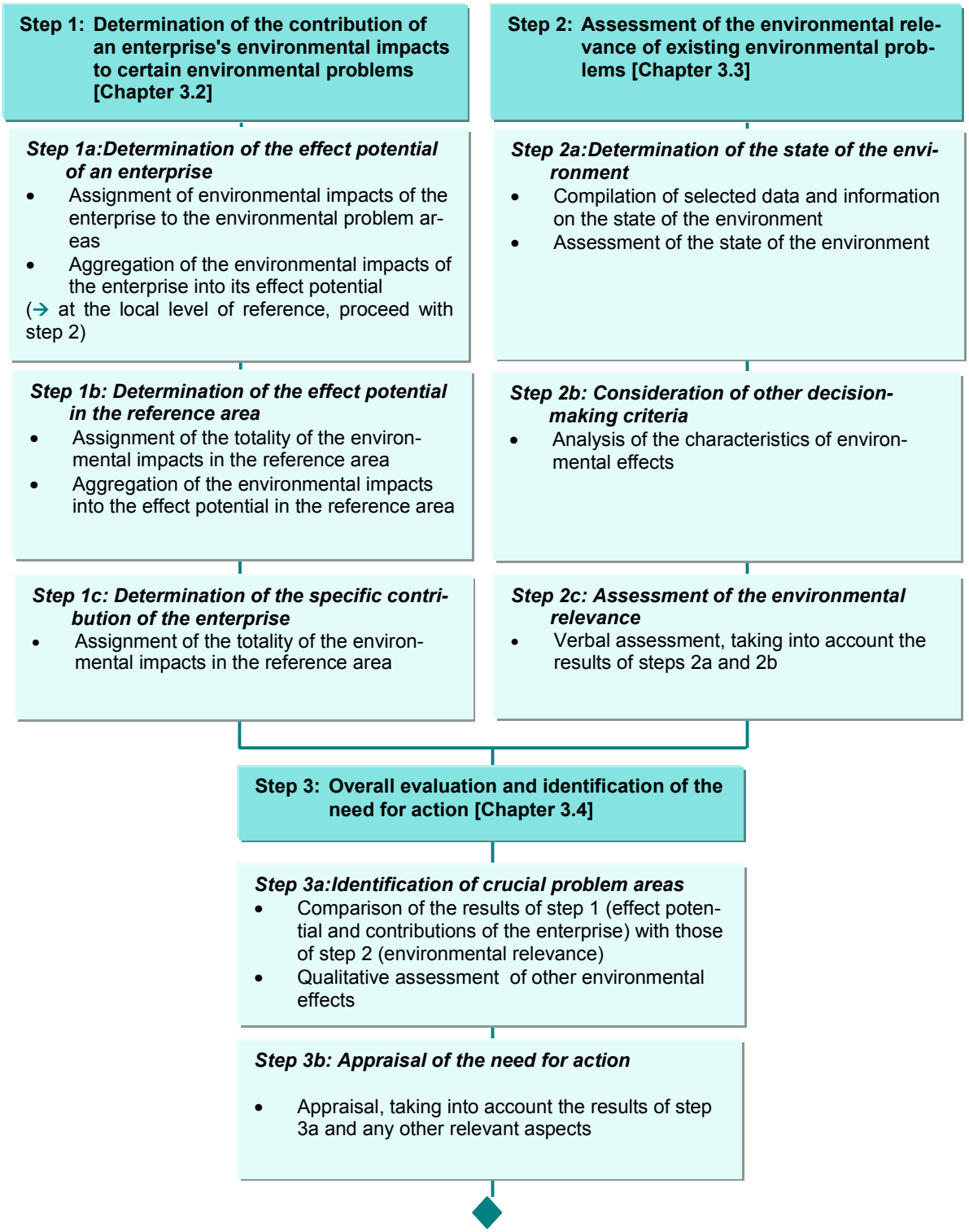
An environmental impact may be listed more than once if contributes to several environmental problems. NO_x emissions, for instance, contribute to eutrophication and acidification, and they also have an effect potential with regard to toxicity to humans and ecotoxicity.

Fig. 3.5: Assignment of environmental impacts of an enterprise to environmental problems (example)

Acidification of the soil	Nitrogen dioxide Sulphur dioxide Chlorinated hydrocarbons Fluorinated hydrocarbons Ammonia
Eutrophication of the soil	Nitrogen dioxide Ammonia
Toxicity to humans	Nitrogen dioxide Sulphur dioxide Chlorinated hydrocarbons Fluorinated hydrocarbons Carbon monoxide Dust particles

An overview of the various environmental impacts of an enterprise and the resulting environmental problems is given in Table 3.1.

Fig. 3.4: Computation steps to assess and evaluate the environmental effects of an enterprise



- **Aggregation of the environmental impacts of an enterprise into its effect potential**

To obtain a measure of the contribution of a business or an organization to an environmental problem, its various environmental impacts must be aggregated into a single entity, the *effect potential of the enterprise*, for each individual problem area. The assessment of environmental impacts resulting from emissions of matter need to reflect that the contributions of different compounds differ in significance. For instance, methane is some 20 times more important as a greenhouse gas than is carbon dioxide. The loads of the various compounds must therefore be multiplied by weighting factors, so-called →*equivalence factors*, to account for their differences in significance. The weighted loads of the different compounds are added in each single environmental problem area to form a single entity termed the effect potential of the enterprise.

Example: Environmental problem of acidification of the soil – regional level of reference –

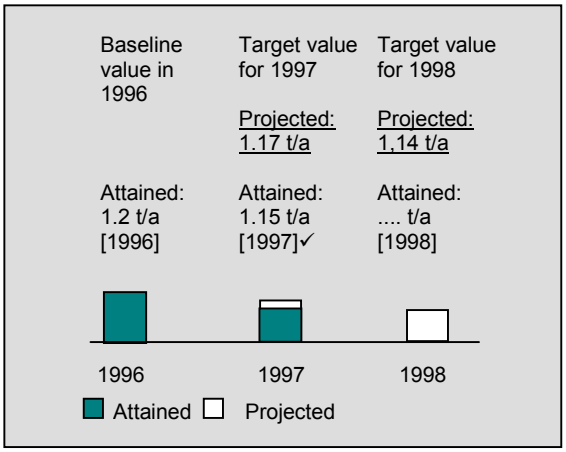
Step 1a: Determination of the effect potential of an enterprise

- Assignment of the enterprise's environmental impacts [→ Checklist 3, Appendix III] to environmental problem areas
- Aggregation to form the effect potential of the enterprise
  - Multiplication of the loads of the compounds by their equivalence factors [→Appendix IV]
  - Addition to form the effect potential of the enterprise

NOx:	**1.22 t/a**	**x**	**0.70**	**=**	**0.85 t/a**
SO_2:	**0.05 t/a**	**x**	**1.00**	**=**	**0.05 t/a**
HCl:	**0 t/a**			**=**	**0 t/a**
HF:	**0 t/a**			**=**	**0 t/a**
NH_3:	**0 t/a**			**=**	**0 t/a**
Effect potential of the enterprise					0.90 t/a

The effect potential of the enterprise can be included as part of the environmental indicators in the environmental information system of the business or organization. Thus, its environmental performance with respect to a given environmental problem area can be evaluated by comparing long-term data series (Fig. 3.6).

Fig. 3.6: Intended annual reduction of the enterprise's acidification potential



At the local reference level, the assessment continues with Step 2 (determination of the state of the environment), whereas additional computation steps are required at the national/global level of reference [→Step 1b].

Step 1b: Determination of the effect potential in the reference area

The preceding section served to determine the effect potential of a business or an organization for each of the various environmental problem areas. In order to determine the enterprise's specific contribution to each single environmental problem area, the effect potential in the reference area must be determined as well. This consists in the sum of the environmental impacts resulting from all of the facilities present in the corresponding region [→Appendix III: Data assessment sheet no. 3]. The relevant environmental impacts are the same as those analyzed in the determination of the effect potential of the enterprise (e.g. the emis-

sions of atmospheric pollutants contributing to acidification). Explanations on the compilation of the data and information required are given in Chapter 4 (step-by-step instructions) and Appendix V (selected data and information on environmental burdens).

The reference area should, if possible, conform to the administrative unit corresponding to the geographical level of reference. This will make it possible to account for exceptional circumstances, such as a relatively high regional environmental burden in relation to the national average.

At the regional level of reference, the effect potential of an enterprise should be based upon the administration district (*Regierungsbezirk*), because data are most accessible at that level. If the business or organization is located in a federal state that lacks this administrative level, the next highest administrative level should be chosen as reference area. If the database is inadequate at the lower administrative levels, then an enterprise may switch to a larger reference area such as the national level. In that case, however, it must not be forgotten that the national average cannot adequately represent the particular environmental burden of the region in which the enterprise is located.

At the national / global level of reference the reference area could comprise Germany. This approach is supported by a good data availability at this level. In the case that the enterprise is situated in a frontier area the European level could be recommendable.

Example: Environmental problem of acidification of the soil – regional level of reference –

Step 1b: Determination of the effect potential in the reference area

- Assignment of the environmental impacts in the reference area → Data assessment sheet 2a, Appendix III] to environmental problem areas
- Aggregation to form the effect potential in the reference area [→Sample processing sheet 2, Appendix III]

NOx:	**131.025 t/a**	**x**	**0.70**	**= 91.718 t/a**
SO2:	**50.181 t/a**	**x**	**1.00**	**= 50.181 t/a**
HCl:	**1.335 t/a**	**x**	**0.88**	**= 1.175 t/a**
HF:	**115 t/a**	**x**	**1.60**	**= 184 t/a**
NH_3:	**608 t/a**	**x**	**1.88**	**= 1.143 t/a**
Effect potential of the reference area				144.400 t/a

Reference area: administration district

Step 1c: Determination of the specific contribution of the enterprise

The specific contributions of the enterprise to the various environmental problem areas may now be determined on the basis of the results of the preceding computation steps. The enterprise's specific contribution is computed by dividing its effect potential by the effect potential in the reference area.

Example: Environmental problem of acidification of the soil – regional level of reference –

Step 1c: Determination of the specific contribution of the enterprise

Division of the effect potential of the enterprise by the effect potential in the reference area

Specific contribution of the enterprise:

$$= \frac{\text{effect potential of the enterprise}}{\text{effect potential in the reference area}}$$

$$\frac{0.90 \text{ t/a}}{144.400 \text{ t/a}} = 6.23 \bullet 10^{-6}$$

The specific contribution of the enterprise is a ratio which characterizes its contribution to the overall burden in the reference area with respect to a given environmental problem. A comparison of all of the enterprise's specific contributions shows the environmental problem areas to which it contributes most. To simplify the comparison, it is best to set the highest value to equal 1 and to express the other values as proportions of 1. An example of such a comparison of the specific contributions of an enterprise is given in Section 3.4 (Fig. 3.9).

3.3 Estimation of the relevance of current environmental problems

The assessment of the environmental effects of a business or organization requires an adequate understanding of the relevance of the environmental problems in question, in addition to the estimate of its own environmental impacts. In other words: How significant is an environmental problem in the local and regional surroundings of the enterprise, or at the national/global level?

The environmental relevance of a given environmental problem can usually be ascertained from the state of the environment. When environmental damage is evident, for instance, or the existing environmental burden indicates that tolerance limits (limits in →ecological carrying capacity) have been attained or exceeded, then it may be assumed that the environmental problem has a corresponding significance in the geographical area in question.

Step 2a: Determination of the state of the environment

Information on the state of the environment is mainly available from the environmental data of government agencies (as basic data, e.g. from surveys, selected →environmental state indicators for specific environmental components etc.). These are either published regularly in environmental reports, or they may be obtained from the authorities.

Detailed procedures for obtaining the data and information required is given in Chapter 4. The tools in Appendix III of this manual [→Appendix III, Checklist no. 4: Data and information from regional administrations and other authorities; various questionnaires] will provide further assistance.

Enterprises to some extent compile their own data on the state of the environment in their vicinity (e.g. on noise immission). Further indications of existing environmental problems and related environmental burdens may be obtained by communicating with neighbors. This concerns, for instance, disturbances due to noise and odors around the site, which may be assessed from the complaints made by neighbors [→Chapter 4: e.g. Checklist no. 1].

The state of the environment is assessed mainly by classifying the environmental burden. The existing evaluation criteria, such as limits, and precautionary and threshold values, provide an assessment framework [→Appendix IV]. Threshold values may, for instance, consist in so-called →No Effect Levels, Critical Levels, and Critical Loads, which are based on effect thresholds determined by scientific methods. In addition, data and information on observed damages of the environment may provide a further understanding of the environmental burden.

A verbal evaluation scale (e.g. with 3 or 5 stages) may be helpful in assessing the potential environmental burden and the state of the environment.

Fig. 3.7: Examples of verbal evaluation scales

Three-stage evaluation scale:
Low – medium – high

Five-stage evaluation scale:
Very low - low – medium – high – very high

When establishing such a scale, values that exceed a tolerance threshold can, for instance, be classified as a very high environmental burden, and the other evaluation stages are adjusted accordingly [→Appendix IV, Evaluation matrix].

So-called →environmental quality targets and environmental action targets [→Appendix IV: Environmental objectives] can also be employed to evaluate the state of the environment. Environmental quality targets are set on the basis of immissions or defined environmental components, and they characterize a desired environmental state (environmental quality). Environmental action targets are based on the cause of a problem and describe the steps required to attain an environmental quality target. Information on the attainment of given environmental objectives may be found in various publications on the state of the environment [→Appendix VII: Bibliography].

Example: Environmental problem of acidification of the soil – regional level of reference -

Step 2a: Determination of the state of the environment

- Compilation of selected data and information on the state of the environment [→ Appendix V]

Environmental indicator selected:
Threshold values (critical loads) exceeded by inputs of acidifying substances into forest soils [Information on the environmental burden are taken from the survey "Excessive Critical Loads of Acid Inputs into Forest Soils" (Source: Environmental Data 1997)]

Result with respect to the reference area:
Threshold values are exceeded in almost all forest sections

- Comparison of the information obtained on the state of the environment to existing evaluation criteria [→ Appendix IV, and VI if applicable]

- The evaluation is based on the environmental quality target "Preservation of the structure and function of sensitive ecosystems by adhering to or remaining below the critical loads for the inputs of acidifying substances".
- The evaluation matrix was based on the threshold value (critical load) for acid inputs into forest soils..

Evaluation matrix:

Classification of the environmental burden	**Attainment of the threshold value**
Very high	> 100 % (exceeding the threshold value)
Very low to high	0 to 100 % (below or at the threshold value)

Classification of the environmental burden in the reference area: **very high**

Step 2b: Consideration of other decision-making criteria

The evaluation of the environmental state with respect to an environmental problem can sometimes be impeded by the lack of generally accepted evaluation criteria or environmental quality and action targets. Other criteria may be employed in these cases to estimate the environmental relevance. These other criteria particularly include the characteristics of the environmental effect brought about by the environmental impact [→ Appendix I: Background information on environmental problem areas].

Fig. 3.8: Characteristics of environmental effects

- Duration of environmental effects
- Spatial extension of an environmental problem
- Irreversibility of environmental effects
- Complexity of the environmental effects, and the existence of serious consequential impacts
- Aggravation of another environmental problem

The environmental problem of the greenhouse effect, for instance, may be characterized by many environmental effects resulting from the primary impact termed "global warming". The reversibility of global climate changes is in doubt as well. Therefore, the problem greenhouse effect is accorded a significant environmental relevance.

Step 2c: Assessment of the environmental relevance

The assessment of environmental relevance is conducted according to the criteria in Step 2a and, if applicable, Step 2b. As in the case of the estimation of the state of the environment, environmental relevance is characterized in verbal form.

The assessment of environmental relevance includes subjective elements, as is the case in all evaluations. The evaluation should be as transparent as possible, so that it can be understood by other parties.

Example: Environmental problem of acidification of the soil - regional level of reference -

Step 2c: Assessment of the environmental relevance
[taking into consideration Step 2a and, if applicable, Step 2b]

Environmental relevance of the environmental problem „acidification of the soil“ in the reference area:
very high

3.4 Overall evaluation and identification of the need for action

The objective of the final overall evaluation is the identification of those environmental problem areas that are of particular importance for a business or an organization, in order to conclude the need for action.

Step 3a: Identification of crucial problem areas

- **Local level of reference**

As already stated, it is easy to establish the cause and effect relationship in an environmental problem at the local level, because of its proximity to the enterprise.

Any need for action results from the environmental relevance of the environmental problem in question in the local vicinity of the enterprise [→ Chapter 4: Practical example "Noise disturbance (local)"].

- **Regional and national/global level of reference**

At the regional and national/global levels, this will not be as simple, because usually a great number of causes contribute to each of the environmental problems [→ Chapter 3.2].

Nevertheless, the evaluation of the crucial problems caused by a business or organization becomes possible by comparing the enterprise's contributions to the various environmental problems (Step 1) with their environmental relevance as determined in Step 2 [→Fig. 3.4].

To account for the significance of the various levels of reference, separate comparisons should be made at the

Table 3.2: Environmental impacts that can be evaluated qualitatively, and resulting environmental problems

Environmental impact (examples) Note: Estimation of the magnitude of indirect environmental impacts from environmental indicators of the enterprise (e.g. quantity of fossil fuel consumed, as opposed to renewable energy sources)	**Environmental problems (examples)** Note: Assessment of the environmental relevance from the characteristics of the environmental effects [→ Fig. 3-8] and/or the environmental burden [→ Appendix V]
UNFINISHED MATERIALS	
Example: Lignite	
▪ Strip mining	⇒ Depression of the water table
Example: Food from conventional agriculture	
▪ Introduction of nutrients into the soil (fertilizers)	⇒ Groundwater pollution by nitrate from fertilizers ⇒ Eutrophication of water bodies
PRODUCTS	
Example: Automobiles	
▪ Consumption of fuel	⇒ Utilization of resources (fossil fuels)
▪ Emission of greenhouse gases and other atmospheric pollutants	⇒ Greenhouse effect and other environmental problems resulting from atmospheric emissions [→ Appendix I]
▪ Noise emissions	⇒ Noise pollution along roads (disturbance of the population and of the fauna)
▪ Land use (disposal)	⇒ Destruction of natural habitats
TRANSPORTATION OF PEOPLE AND GOODS (INSIDE AND OUTSIDE THE REGION)	
▪ Consumption of fuel (use of non-renewable sources of energy)	⇒ Utilization of resources (fossil fuels)
▪ Emission of greenhouse gases and other atmospheric pollutants	⇒ Greenhouse effect and other environmental problems resulting from atmospheric emissions [Appendix I]
▪ Noise emissions	⇒ Noise pollution along roads (disturbance of the population and of the fauna)
▪ Land use (use of the public road network)	⇒ Fragmentation of the landscape ⇒ Destruction of natural habitats

regional and for national/global reference levels (if different reference areas are chosen for analyses at the regional and national/global levels, then the resulting specific contributions of the enterprise cannot be compared, because of the data's different reference bases).

First of all, it is necessary to identify environmental problem areas having high and very high relevance. Those where the specific contribution of the enterprise is relatively high need to be considered crucial. In our example (Fig. 3.9), this concerns the environmental problem areas "summer smog" and "toxicity to humans", due to dust pollution. The environmental problem "destruction of natural habitats" is of special importance as well, because it has very high environmental relevance, even though the enterprise's contribution is of medium significance.

Environmental problems with high and very high relevance and a low or very low specific contribution of the enterprise will follow in second place. These environmental problem areas may be less significant with regard to the enterprise's specific contribution, but it needs to be kept in mind that the sum of the burdens caused by numerous facilities having each a small contribution may add up to a serious environmental problem. This might be the case, for instance, with regard to the environmental problems of eutrophication and acidification of the soil.

Another secondary environmental problem is the eutrophication of water bodies, with medium environmental relevance and a medium specific contribution of the enterprise.

Environmental problems of low and very low relevance may be judged as having minor significance, as long as there are no other aspects of relevance to the evaluation, such as non-compliance with legal standards [→ Step 3b]. Significance is especially low in environmental problem areas with low and very low environmental relevance, to which the enterprise's specific contribution is also low or very low.

- **Qualitative evaluation**

Data on the environmentally relevant issues concerning a business or an organization are not always adequate and reliable enough to permit a quantitative assessment of the environmental impacts. This is particularly true for the indirect environmental impacts of unfinished materials and of products, but it may also apply to the environmental effects of the transportation of people and goods with vehicles other than those of the enterprise [→Table 3.2]. In these cases, it will be possible to conduct a qualitative analysis of the environmental impacts and resulting environmental problems. The unfinished materials, products and transports may be assessed by comparing their environmental impacts with alternatives having a higher degree of environmental compatibility.

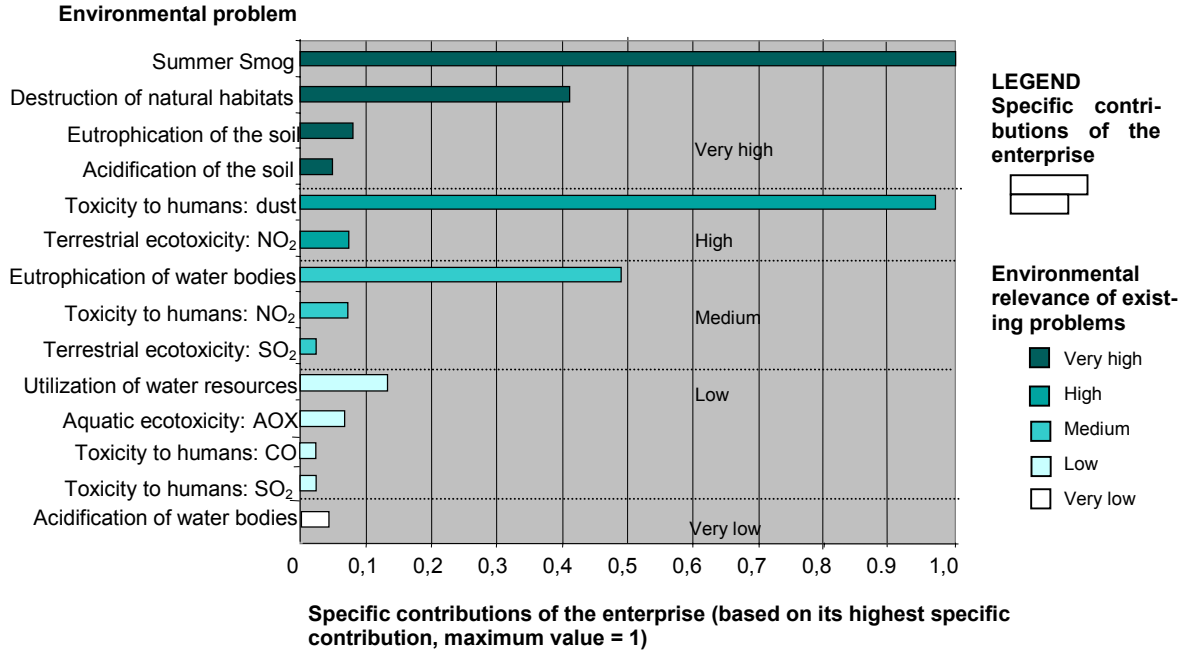
The estimation of environmental relevance may be carried out in analogy to the quantitative evaluation [→ Fig. 3.4, Step 2]. Since the exact geographical areas where environmental impacts occur are often unknown, it will only be possible to estimate the general environmental relevance of some of the problems [→ Fig. 3.9 and Appendix V].

Step 3b: Appraisal of the need for action

The problem areas identified in Step 3a form the basis for decisions regarding the actions to protect the environment on the part of the business or the organization.

Decisions are required most of all with respect to those environmental problem areas which have been identified as the most critical. In these problem areas, it is necessary to study possibilities to improve the situation as far as possible from a technological and organizational point of

Fig. 3.9: Comparison of the specific contributions of a enterprise and the relevance of existing environmental problems (regional level of reference)



view. In our example, this concerns the problem of summer smog, for instance, where measures to reduce the emissions of volatile organic compounds would need to be considered.

There is further need for action – albeit with less urgency – in the case of environmental problems that take second place in the overall evaluation. If the enterprise only makes a small contribution to a problem having high or very high environmental relevance, then the company's actions to reduce the corresponding impact potential will hardly affect the environment. But if a high load of pollution is caused by a great number of industrial facilities, each of which only contributes a little to the total load, then voluntary steps undertaken in concert by the different companies may improve the state of the environment.

In practice, a business or organization taking its final decision on the need for action will include additional criteria besides the evaluation procedure described in Step 3a.

The following issues may be of importance:

- Does the facility approach the legal emission limits?

  This particularly concerns compounds of importance in the environmental problems "toxicity to humans" and "ecotoxicity".

- Is there any remaining potential for improvements?

  Additional information on the optimization potential in businesses and organizations may be found by comparing different methodologies and by

studying the procedures employed by other enterprises.

- Has the enterprise set environmental objectives in the past and were these attained, so that a trend to reduce its corresponding effect potential already exists?
- How are the causes of environmental problems structured? Do many enterprises each make a small contribution to an environmental problem, or is one sector or one facility the principal cause of that environmental problem?

Table 3.3: Comparison of the specific contributions of an enterprise and the relevance of existing environmental problems (regional level of reference)

Point	Critical problem / class	Environmental relevance (Step 2)	Specific contribution of the enterprise (Step 1)	Decision-making criteria to appraise the need for action Note: Need for action always exists when legal limits or other legal provisions are not being met
1a	Class 1	High / very high	High / very high	Need for action is obvious
1b		High / very high	Medium	See above. Need for action is somewhat less urgent than in Point 1a
2a	Class 2	High / very high	Low / very low	Need for action exists when many facilities make small contributions to an environmental problem (examination of the problem structure)
2b		Medium	High / very high	Need for action exists from the standpoint of sustainability
2c		Medium	Medium	Need for action exists from the standpoint of sustainability (but less than in Point 2b)
3a	Class 3	Medium	Low / very low	Need for action exists when many facilities make small contributions to an environmental problem (examination of the problem structure) (but less than in Point 2a)
3b		Low / very low	High / very high	Need for action exists from the standpoint of sustainability (but less than in Point 2b)

3.5 Examples of environmental action plans

The planning of measures for ecological optimization depend on many factors and will vary between enterprises. The implementation of steps to minimize the effect potentials of a business or an organization depends on their technological and organizational feasibility, among other things. The economic framework will also have a strong influence on the planning of ecological measures. Therefore, this manual cannot provide any generally applicable objectives, and must necessarily be limited to naming some examples [Fig. 3.10].

Fig. 3.10: Examples of steps towards the reduction of the effect potentials of an enterprise

Production sector:

- Tracing emissions to individual production processes as a basis for the planning of further action
- Technological planning of mechanical equipment (optimization of machinery, alternative processing methods)
- Use of unfinished materials having a higher degree of environmental compatibility
- Ecological product planning

Transportation sector:

- Optimization of the logistics
- Transportation of goods by rail
- Selection of environmentally safe means of transportation for business trips
- Changing the tires of the vehicles used by the enterprise

Infrastructure:

- Opening up of sealed terrain, or changes in the type of surface on the site of the facility
- Planting of greenery on the site of the facility

4 Practical step-by-step instructions

This chapter shows how a business or an organization can proceed step by step to determine the potential environmental effects of its activities. Practical examples will facilitate comprehension.

The procedure consists of two phases. In Phase I, an enterprise selects the *environmental impacts* it desires to analyze more closely for their *environmental effects* [→Chapter 2]. In Phase II, these *environmental impacts* and the resulting *environmental effects* will be assessed and evaluated. The appropriate methodology has been described in → Chapter 3.

An overview of the necessary steps is given in Fig. 4.1. Appendices I to VII provide a number of tools for each step, including checklists, data assessment sheets, and other worksheets.

4.1 Phase I: Assessment of the relevant environmental impacts

Step 1: Collecting the data and information on the enterprise

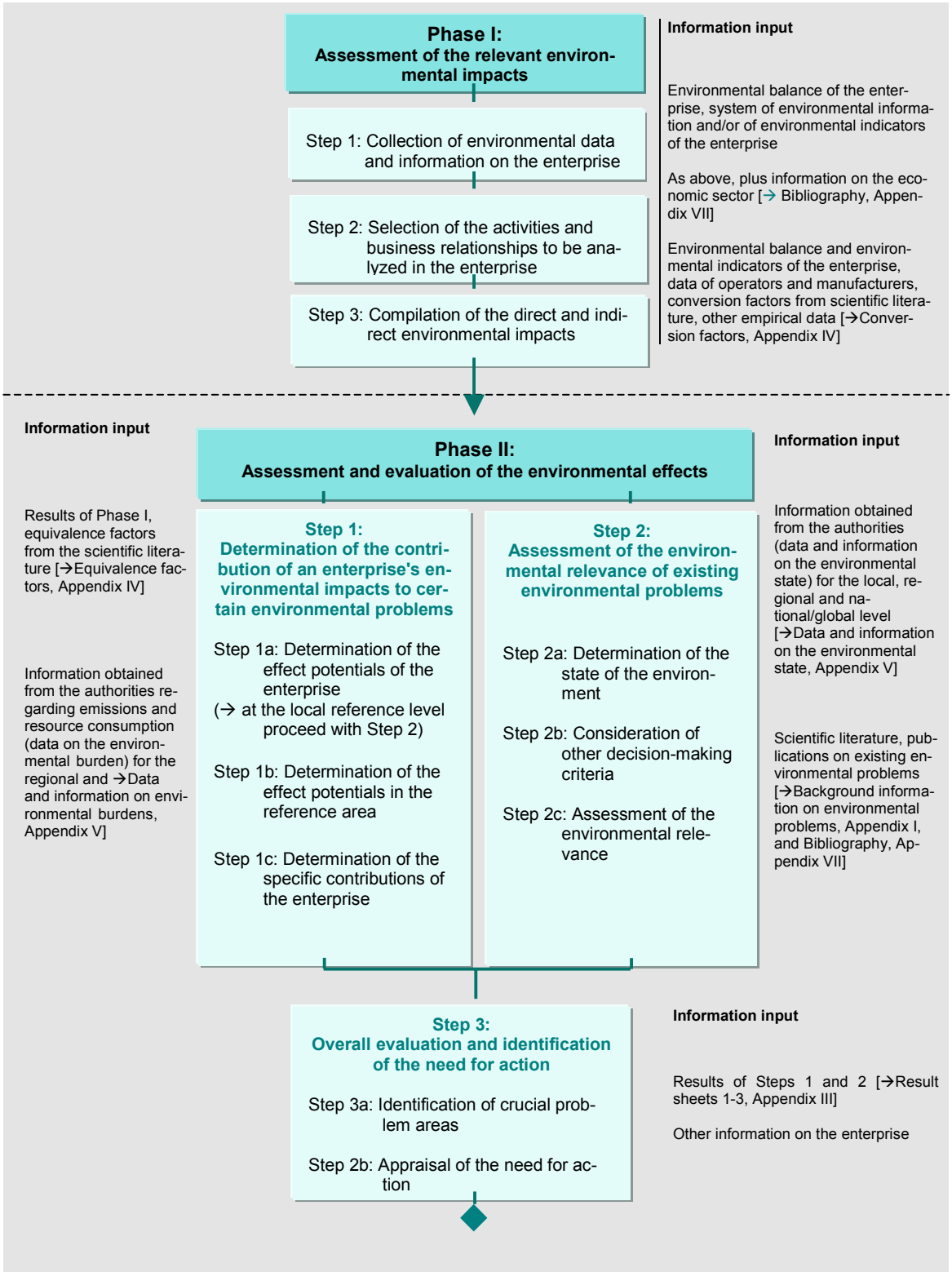
Every business and organization already disposes of data and information permitting a determination of direct and, to some extent, of indirect environmental impacts. Absolute indicators based on a common time frame (the fiscal year or the calendar year), such as the annual consumption of water, are particularly useful.

These data are usually included in the →environmental balance of the enterprise. Businesses and organizations having their own environmental controlling system can make use of the available → environmental indicators. A manual entitled "*Betriebliche Umweltkennzahlen*" ("Environmental Indicators of Businesses and Organizations"), published by the Federal Ministry of the Environment and the Federal Environmental Agency provides an overview of environmental indicators and their various uses for environmental protection measures by enterprises [→ Appendix VII).

Any available information on the environmental effects that will be of value in Phase II may already be collected at this stage. This includes for instance, data of measurements, or complaints by neighbors about noise disturbances in the vicinity.

Checklist no. 1 "Relevant environmental indicators of the enterprise" [→ Appendix III] will help in compiling the information required. This is illustrated below using the example of a paint factory.

Fig. 4.1: Overview of the phases and steps to assess and evaluate the environmental impacts and effects of a business or organization



Checklist no. 1: Relevant environmental indicators of the enterprise (numerical example: paint factory)			
Environmental indicators			
Indicators of matter and energy			
INDICATORS OF INPUT			
1. Energy consumption and energy sources	Electricity (from outside source) Heat Fossil fuels Natural gas Fuel oil Diesel oil Energy from renewable sources Others - Diesel fuel from rapeseed	5.620.400 - 12.984.592 1.660.000 1.049.391 - 14.992	kWh/a kWh/a kWh/a kWh/a kWh/a kWh/a kWh/a kWh/a
	→ Checklist no. 2, Point 3.1 and 3.2: Indirect environmental impacts of prior production of the energy consumed		
2. Consumption of materials	• Unfinished materials produced from non-renewable raw materials (glycols, acids, solvents etc.) • Unfinished materials produced from renewable raw materials (vegetable oils) • Other materials (packaging)	14.226 443 557	t/a t/a t/a
	→ Checklist no. 2, Point 4.1: Indirect environmental impacts of prior production stages		
3. Consumption of water	• Municipal water • Water extracted by the enterprise itself - Surface water (pond water) - Groundwater and spring water (from a well)	3.583 244.000 23.644	m³/a m³/a m³/a
	→ Checklist no. 2, Point 1: Direct environmental impacts, and Point 3.3: Indirect environmental impacts of the prior extraction of water		
INDICATORS OF OUTPUT			
4. Emission of waste air	• CO_2 • NO_2 • SO_2 • CO • Organic solvents • Dust • Other substances	3.363 1.22 0.05 1.98 16.27 2.70 -	t/a t/a t/a t/a t/a t/a t/a
	→ Checklist no. 2, Point 1: Direct environmental impacts and Point 2 to 4: Indirect environmental impacts due to transport, prior and subsequent supply and disposal, prior and subsequent production stages, and consumers		
5. Effluent wastewater	Direct effluents: • Volume of effluent (uncontaminated cooling water) • Total nitrogen • Ammonia nitrogen • Total phosphorus • COD • Heavy metals • Other substances	 244.000 - - - - - -	 m³ t/a t/a t/a t/a t/a t/a
	→ Checklist no. 2, Point 1: Direct environmental impacts		

	Indirect effluents: • Volume of effluent (water from sanitary facilities and laboratory) • Effluent loads: - Total nitrogen - Ammonia nitrogen - Total phosphorus - COD - Heavy metals - Other substances	3.583 - - no precise data - - (pollution levels similar to those of municipal sewage)	m³ t/a t/a t/a t/a t/a t/a
	→ Checklist no. 2, Point 3.4: Indirect environmental impacts of municipal wastewater treatment		
6. Production of solid wastes	Disposal by the enterprise itself: • Wastes for incineration or thermal re-use • Wastes for disposal on landfill Outside disposal: • Disposal in the municipal/regional area - Wastes for incineration or thermal re-use - Wastes for disposal on landfill • Disposal outside the municipal/regional area - Wastes for incineration or thermal re-use - Wastes for disposal on landfill • Wastes for recycling	 - - - 757.1 (itemize for further evaluation) 113.3	 t/a t/a t/a t/a t/a
	→ Checklist no. 2, Point 3.5: Indirect environmental impacts of waste disposal		
7. Products	• Environmentally relevant products - Synthetic resins - Varnish paints	 3.877 9.616	 t/a t/a
	→ Checklist no. 2, Point 4.2: Indirect environmental impacts of subsequent production stages, and of use of the products by consumers		
Indicators concerning storage			
8. Quantity of storage	• Quantity of materials stored (m3 or t) belonging to certain water hazard classes, and • Hazard levels of the equipment in the enterprise [classification according to administrative ordinance] • Volume of stored materials classified as E=explosive, 0=oxidizing, F+=extremely flammable, F=flammable, EZ=flammable, according to the Ordinance on Hazardous Materials (Gefahrstoffverordnung), or that are considered AII, AI or B materials (conversion to AI equivalents) according to the Ordinance on Flammable Liquids (Verordnung über brennbare Flüssigkeiten) • Data on equipment that is notifiable or subject to licensing (indicating high or very high hazard potential) Alternatively: • Quantity of materials used belonging to the hazardous materials listed above, according to the Ordinance on Hazardous Materials or on Flammable Liquids (see paragraph on materials)	See storage lists	m^3 or t A, B, C, D-classification m^3 or t
	→ Checklist no. 2, Point 1: Direct environmental impacts		

Indicators concerning the infrastructure			
9. Land use	• Total area of the facility - Surface area of buildings - Surface area of roads - Green spaces - Other undeveloped surfaces • Outsourced sectors of the enterprise ….. same as above	136.500 30 70 - -	m² % % % m² bzw. %
	→ Checklist no. 2, Point 1: Direct environmental impacts and Point 2 to 4: Indirect environmental impacts due to transport, prior and subsequent supply and disposal, prior and subsequent production stages, and consumers		
Indicators of transportation			
10.Transportation of goods and people	Company vehicles and commuter traffic: Traffic and transportation in the municipal/regional vicinity: • Transportation of goods • Transportation of goods: daily arrivals and departures to and from the site • Business trips • Commuter traffic - Automobiles by type of engine (see Appendix III, Annex 1e) Traffic and transportation outside the region: • Transportation of goods - Trucks by size class (see Appendix III, Annex 1e) • Business trips - Automobiles by type of engine (see Appendix III, Annex 1e) Transportation by external service providers	 no data no data 800,000 no data 390.000 1.600.000 no data	 Veh.km/a, or tkm/a Number/day Veh.km/a Veh.km/a Veh.km/a Veh.km/a
	• Transportation of hazardous substances, total • Transportation of hazardous substances, as fraction of total	no data no data	Number %
	→ Checklist no. 2, Point 2: Direct / indirect environmental impacts due to transports		
Indicators from the list of complaints against the enterprise			
11. Noise	Complaints about noise in the vicinity of the enterprise	0	Number/a
	→ Checklist no. 2, Point 1: Direct environmental impacts		
12. Odors	Complaints about odors in the vicinity of the enterprise	1 (odors mostly due to sewage treatment plant)	Number/a
	→ Checklist no. 2, Point 1: Direct environmental impacts		
Other indicators (quantitative data)			
13. Noise	Noise immissions on site and in the vicinity (rating sound levels)	Space points: Residential building: 38 Open air: approx. 38	db(A) db(A)
	→ Checklist no. 2, Point 1: Direct environmental impacts		
14. Odors	Duration of odor pollution (according to VDI 3940) Nuisance index (according to VDI 3883, sheet 1)		H_m I_k (value of 1 – 100)
	→ Checklist no. 2, Point 1: Direct environmental impacts		

Step 2: Selecting those activities and business relationships of the enterprise that require closer analysis

Based on the data and information compiled in Step 1, it will become possible to select those environmental impacts that are of relevance. The focus will depend on the economic sector to which the business or the organization belongs, as well as other characteristics of the enterprise. Checklist no. 2 "Scoping" [Appendix III] will help in this task.

How scoping can be conducted is shown below using the example of the paint factory. It shows that both direct and indirect environmental impacts may be significant and thus acquire relevance for the analysis. Scoping would provide a different result, for instance, in the case of an energy plant, the analysis of which would focus on the direct environmental impacts, due to the characteristics of the enterprise (self-sufficiency with respect to energy, usually insignificant utilization of water services due to its own extraction of water).

Direct and indirect environmental impacts vary, depending on the economic sector. The profiles of the different economic sectors available from environmental statistics data will aid in conducting an assessment [→ Appendix VII, reference 26].

Checklist no. 2: Scoping (e.g. paint factory)			
Relevant environmental impacts			**Remarks**
	Quantitative	Qualitative	
Direct environmental impacts (site of the facility)			
1. Enterprise in the region:			
- Utilization of groundwater, spring water, or surface water (extraction)	☒	☐	
- Land use (infrastructure of the facility, dumping of wastes on a landfill of the enterprise	☒	☐	
- Direct discharge of effluents into a drainage ditch	☐	☐	
- Emissions / immissions of noise	☒	☐	
- Emissions of atmospheric pollutants, and emissions of odors	☒	☐	
- Other emissions (soil)	☐	☐	
- Risk potential due to the storage of materials hazardous to waters, and of materials constituting a fire hazard	☒	☐	
Direct / indirect environmental impacts:			
2. Transportation within and outside the region			
- Use of road facilities	☒	☐	
- Emissions / immissions of noise	☒	☐	
- Emissions of atmospheric pollutants	☒	☐	
- Utilization of resources (fossil fuels)	☒	☐	

Indirect environmental impacts (site of the facility / prior and subsequent production stages / consumers)			
3. Prior and subsequent supply and disposal:			
3.1 Energy supply (heat) in the region:			
- Emissions of atmospheric pollutants	☐	☐	
- Utilization of resources (fossil fuels)	☐	☐	
3.2 Energy supply (electricity) via the national network:			
- Emissions of atmospheric pollutants	☒	☐	
- Utilization of resources (fossil fuels)	☒	☐	
3.3 Water supply in the region:			
- Utilization of groundwater, spring water, or surface water	☒	☐	
3.4 Wastewater disposal in the region:			
- Discharge of effluents into water bodies (after treatment in a public sewage treatment plant)	☒	☐	
- Land use due to dumping of sewage sludge	☒	☐	
- Emissions of atmospheric pollutants due to incineration of sewage sludge	☒	☐	
3.5 Waste disposal within and outside the region:			
- Land use (landfill)	☒	☐	
- Emissions of atmospheric pollutants (incineration)	☒	☐	
4. Prior and subsequent production stages within and outside the region, and consumers:			
4.1 Prior production stages within and outside the region:			
- Utilization of resources (fossil fuels, raw materials)	☒	☒	Unfinished materials: qualitative data only in some cases (→ Data assessment sheet 1, Annex 1d)
- Utilization of groundwater, spring water, or surface water	☐	☐	
- Land use (exploited surfaces, areas used for agriculture and forestry, landfills	☐	☒	
- Land use due to dumping of wastes	☐	☐	
- Discharge of effluents	☐	☐	
- Emissions of atmospheric pollutants	☒	☐	
- Other environmental impacts	☐	☐	
4.1 Subsequent production stages, and product use by consumers, within and outside the region:			
- Utilization of resources (fossil fuels, raw materials)	☐	☐	
- Land use due to dumping of wastes (disposal of product)	☐	☒	
- Discharge of effluents (use of product)	☐	☐	
- Emissions of atmospheric pollutants (use of product)	☐	☒	
- Other environmental impacts	☐	☐	
→ Continue with Data assessment sheet no. 1, Appendix III			

Step 3: Compiling the direct and indirect environmental impacts

The direct and indirect environmental impacts can now be determined from the data and information compiled, as well as on the basis of the activities and business relationships selected for analysis. To this end, the data of Checklist no. 1 that have not been eliminated by Checklist no. 2 are transferred to Data assessment sheet no. 1 "Direct and indirect environmental impacts [→ Appendix III]. At this point we begin to discriminate where environmental impacts arise: within, or outside the region in which the business or the organization being analyzed is located. Due to space limitations, the corresponding data sheet for the paint factory will not be reproduced here.

In some cases it will not be possible to transfer figures and other information from Checklist no. 1 to Data assessment sheet no. 1. This applies to data that do not themselves represent environmental impacts, such as data on energy consumption, and on the volume of transportation and of wastes produced [→ Chapter 2.2]. An intermediate step is required in these cases: The environmental impacts must first be computed from the enterprise's inputs and outputs before they can be entered into the data assessment sheet. Assistance in carrying out this intermediate step is provided by Annexes 1a to 1j in Data assessment sheet no. 1 [→ Appendix III].

Information on the type and magnitude of the environmental impacts of various inputs and outputs is sometimes available from business associates. On the other hand, it is equally possible to compute them from empirical conversion factors, which have usually proved to be very reliable [→ Appendix III].

4.2 Phase II: Assessment and evaluation of environmental effects

The potential environmental effects of a business or an organization, i.e. its contribution to certain environmental problems, is assessed in Phase II on the basis of its environmental impacts and of the state of the environment.

The basic procedure is described in → Chapter 3, and its practical implementation is explained step by step below, with particular reference to the tools provided in the Appendix. For a better understanding, the procedure is illustrated using the environmental problem "acidification of the soil" as a practical example. Other examples are given further below, and a complete list of examples is in → Appendix II.

Step 1a: Determining the effect potential of an enterprise

First, the environmental impacts of the business or organization in Data assessment sheet no. 1 are sorted by environmental problem area and by geographical reference level (local, regional, national/ global) [→ Checklist no. 3: Assignment of environmental impacts of the enterprise to environmental problems, Appendix III]. This clarifies the environmental problems to which the enterprise contributes and, therefore, on which it should focus. The values may be transferred directly to the Processing sheets [→ Appendix III, Sample processing sheets 1 to 3, Step 1a], but they may have to be weighted [→ Chapter 3.2] by multiplying with equivalence factors [→ Appendix IV] if necessary.

Background information on the various environmental problem areas is provided in Appendix I, and practical examples of the assessment and evaluation procedure are given in the present section and in → Appendix II.

Checklist no. 3: Assignment of the environmental impacts of an enterprise to environmental problems					
→ Enter the results from Checklist no. 1 and/or Data assessment sheet no. 1					
Environmental problem (numerical example)	**Relevant environmental impacts**				**Unit**
			Direct environm. impact	Indirect environm. impact	
Local reference level					
Disturbances due to noise (paint factory)	-- Irrelevant here, the environmental effects can be analyzed directly --				
Disturbances due to odors (chemical plant)					
Visual disturbances (food processing plant)					
Warming of the surface (food processing plant)	Sealing of the surface	Percentage of the surface area of the plant that is sealed	79	-	%
Fire hazard (paint factory)	Proportion of substances that constitute a fire hazard Number of substances that constitute a fire hazard	Explosive materials Oxidizing materials Extremely flammable materials Flammable materials or AII-class substances AI-class substances B-class substances	 approx. 50 25 0 0.1	-	% % % % % % %
Hazard to groundwater (paint factory)	Proportion of substances hazardous to water or hazard levels of the equipment in the facility and proportion of total quantity stored	Hazard classes B, C and D	73	-	%
Regional reference level					
Summer smog (paint factory)	Regional emissions of volatile organic compounds	NMVOC	16.4		t/a
Acidification of the soil (paint factory)	Regional emissions of acidifying atmospheric pollutants	NO_2 SO_2 HCl HF	1.53 0.08		t/a t/a
Acidification of water bodies (paint factory)	Regional emissions of acidifying atmospheric pollutants	NO_2 SO_2 HCl HF	1.53 0.08		t/a t/a
Eutrophication of the soil (paint factory)	Regional emissions of eutrophicating atmospheric pollutants	NO_2	1.53		t/a
Eutrophication of water bodies (chemical plant)	Regional discharge of nutrients and of oxygen-consuming substances into water bodies	Total nitrogen Ammonia nitrogen Total phosphorus COD		0.022 - 0.015 1.80	t/a t/a t/a

Toxicity to humans (thermal power plant) -Inhalation	Regional emissions of atmospheric pollutants having potential toxicity to humans	NO_2 SO_2 HCl HF CO Dust Other substances (e.g. lead, cadmium, thallium)	352 23.7 - - 49.3 6.6	Insignificant (<1% of the direct emissions)	t/a t/a t/a t/a t/a t/a
-Food chain	Regional emissions of atmospheric pollutants that may accumulate in the food chain	Other substances (e.g. lead, cadmium, thallium, polychlorinated hydrocarbons)	-		t/a
Terrestrial ecotoxicity (thermal power plant)	Regional emissions of atmospheric pollutants having potential ecotoxicity	NO_2 SO_2 HCl HF Other substances (e.g. copper, nickel, zinc)	352 23.7 - -	Insignificant (<1% of the direct emissions)	t/a t/a t/a t/a
Aquatic ecotoxicity (thermal power plant)	Regional emissions of atmospheric pollutants having potential ecotoxicity to waters	AOX Heavy metals such as Lead Cadmium Copper Mercury Zinc	0.0346 0.0026 0.00015 0.100 0.00015 0.077	-	t/a t/a t/a t/a t/a t/a
Resource utilization - water (thermal power plant)	Water consumption	Groundwater and spring water Surface water and riverbank filtrate	- 2,784,941	1,979.91 2,458.10	m³/a m³/a
Destruction of natural habitats (food processing plant)	Land use in the region	Area of the plant Landfill space Exploited area Areas used for agriculture and forestry	2.4 - - -	- 0.014 - no data (qualitative analysis)	m² m² m² m²
National/global reference level					
Greenhouse effect (metal processing plant)	Emissions of greenhouse gases within and outside the region	CO_2 CH_4 N_2O Other substances (e.g. FCHC 11/-12/ -13/ -113/-114/-115, CCl_4, methyl chloride)	1,896 - - -	32,116 75 1.40	t/a t/a t/a t/a
Ozone degradation in the stratosphere (not relevant to any of the present examples, but needs to be considered by any enterprise)	Emissions of ozone-degrading compounds within and outside the region	N_2O Other substances (e.g. FCHC, brominated halones, halogenated hydrocarbons)	-	-	t/a t/a

Resource utilization (metal processing plant)	Consumption of resources within and outside the region	Fossil fuels: Lignite Anthracite Natural gas Heating oil Other raw materials:	 - - 306,672 420,708 no data	 - - 730.268 88 -	t/a t/a t/a t/a t/a
Summer smog (paint factory)	Emissions of volatile organic compounds within and outside the region	Organic solvents Other NMVOC	16,6	0,823	t/a
Acidification of the soil (paint factory)	Emissions of acidifying atmospheric pollutants within and outside the region	NO_2 SO_2 HCl HF	4.72 0.0861 - -	5.76 2.81	t/a t/a t/a t/a
Acidification of water bodies (paint factory)	Emissions of acidifying atmospheric pollutants within and outside the region	NO_2 SO_2 HCl HF	4.72 0.0861	5.76 2.81	t/a t/a t/a t/a
Eutrophication of the soil (paint factory)	Emissions of eutrophicating atmospheric pollutants within and outside the region	NO_2	4,72	5,76	t/a
Eutrophication of water bodies (paint factory)	Discharge of nutrients and of oxygen-consuming substances into water bodies within and outside the region Emissions of eutrophicating atmospheric pollutants within and outside the region [1i]	Total nitrogen Ammonia nitrogen Total phosphorus COD/BOD NO_2		0.05 - 0.27 0.24 (estimates) 4.72	t/a t/a t/a t/a t/a
Disturbances due to noise (paint factory)	Annual volume of transportation within and outside the region		2,870,000		Veh.km Tkm
Fragmentation of the landscape (paint factory)	Annual volume of transportation within and outside the region		2,870,000		Veh.km Tkm
Destruction of natural habitats (food processing plant)	Land use within and outside the region	Area of the plant Landfill space Exploited area Areas used for agriculture and forestry	Cf. regional reference level - -	Cf. regional reference level. No quantitative data on land use due to disposal outside the region,	m²
			and to prior production stages (→ qualitative analysis)		
→ Transfer to the Data processing sheets on individual environmental problems					

[1] accounts for the eutrophication of the marine environment via the atmospheric pathway

Step 1b: Determining the effect potential in the reference area

Only few *environmental impacts* of a business or an organization permit a direct inference regarding their *environmental effects* [→ Appendix III, Checklist no. 1, Point 11 to 14]. In the case of most other *environmental impacts*, it is first necessary to determine the effect potentials in the reference area. Information on the magnitude of all emissions and of the consumption of resources in the area needs to be compiled as well. These data are available from generally accessible publications [→ Appendix VII], or they can be obtained from the relevant authorities. However, processing service, and organization of the data differ considerably from state to state, as well as between administrations. For this reason, relations with the appropriate authorities are important.

To clarify which environmental information plays a role in assessments of the various environmental problem areas, → Appendix V provides an overview of the relevant burden data and environmental state data, and names the sources where they may be obtained. Checklist 4 and standard questionnaires [→ Appendix III] may help to simplify the necessary inquiries. As Steps 2a, 2b, and 2c also necessitate inquiries for data – in this case with regard to the environmental state - it will save work to coordinate these assessments.

The results are entered into Data assessment sheets no. 2a and 2b [→ Appendix III], and subsequently into Sample processing sheets 2 and 3 [→ Appendix III], as already carried out in Step 1.

Step 1c: Determination of the specific contribution of the enterprise

This step serves to determine the contribution of the business or organization to certain *environmental impacts* at the regional and national/global level. This requires forming the quotient of the effect potential of the enterprise [→ Step 1a] and the effect potential in the reference area [→ Step 1b]. The result is the specific contribution of the enterprise, which is also entered into Sample processing sheets 2 and 3 [→ Appendix III]

Step 2a: Determining the state of the environment

Data on the *environmental state* are collected regularly by municipal and other authorities, and they are frequently published in the form of environmental reports [→ Appendix VII]. The procedures and tools are described in → Step 1b.

The results are entered into Data assessment sheet no. 3 [→ Appendix III] and then transferred to Sample processing sheets 1, 2 and 3 [→ Appendix III]. The environmental state is estimated in verbal form. Possible assessment criteria are given in → Appendix IV.

Step 2b: Consideration of other decision-making criteria

It may prove difficult to evaluate environmental problems for which "hard" assessment criteria do not yet exist. This requires a qualitative evaluation of the environmental effects according to criteria such as those illustrated in → Fig. 3.8. Background information on the environmental problems [→ Appendix I]

may help in making an estimate. The results of Step 2b are equally transferred to Sample processing sheets 1, 2 and 3 [→ Appendix III].

Step 2c: Assessing the environmental relevance

Taking into account Steps 2a and 2b, the relevance of the environmental problems in question is now estimated and entered into Sample processing sheets 1, 2 and 3 for the three reference levels [→ Appendix III] as well.

The above steps are illustrated by the practical examples listed in Table 4.1. Since small differences exist, depending on the reference level, examples have been selected for the local, regional and national/global reference level. A compilation of all the environmental problems listed here can be found in → Appendix II.

Table 4.1 Practical examples for the completion of the Sample processing sheets

Local reference level		
1	Disturbance due to noise	Chapter 4 / Appendix II
2	Disturbance due to odors	Appendix II
3	Visual disturbance	Appendix II
4	Warming of the surface	Appendix II
5	Fire hazard	Appendix II
6	Potential threats to the groundwater supply	Appendix II
Regional level of reference		
7	Summer smog	Appendix II
8	Acidification of the soil	Chapter 3 and 4/ Appendix II
9	Acidification of waters	Appendix II
10	Eutrophication of the soil	Appendix II
11	Eutrophication of waters	Appendix II
12	Toxicity to humans / inhalation	Appendix II
13	Terrestrial ecotoxicity	Appendix II
14	Aquatic ecotoxicity	Appendix II
15	Consumption of resources (water)	Appendix II
16	Destruction of natural habitats	Appendix II
National/global level of reference		
17	Greenhouse effect	Chapter 4 / Appendix II
18	Consumption of resources	Appendix II
19	Disturbances due to traffic noise	Appendix II
20	Fragmentation of the landscape	Appendix II

No. 1: Environmental problem of noise (local level); e.g. paint factory

Step 1: Determination of the magnitude of the environmental impacts concerning the environmental problem of disturbance due to noise [Chapter 3.2]

Step 1a: Determination of the effect potential of the enterprise

■ Assignment of the environmental impacts of the enterprise

Emissions of noise including, if applicable, noise emissions resulting from transportation on the site of the facility

Evaluation from the perspective of immissions (→ Step 2)

Step 1b: Determination of the magnitude of the effect potential of the enterprise

■ Other remarks regarding the effect potential

Noise emissions are of particular importance in the case of this enterprise, due to adjoining residential areas

Step 2: Assessment of the environmental relevance of the problem of disturbance due to noise in the vicinity of the enterprise [Chapter 3.3]

Step 2a: Determination of the environmental state

- Compilation of selected data and information on the environmental state [see Appendix V]
  - Determination of rating sound levels on the basis of measurements at outdoor space points
  - Determination of rating sound levels on the basis of predicted noise immissions
  - Information on zoning status of the neighborhood

  [Determination of rating sound levels according to the Technical Guideline on Noise (*TA Lärm, VDI 2058*), or its revised version]
  - Number of complaints about noise disturbance, if applicable

  Evaluation according to the Technical Guideline on Noise

  [Evaluation matrix → Appendix IV.2, B.1]

Zoning characteristics	**Outdoor noise - day/night in db(A)**	**Environmental burden**
Area with commercial facilities, in which neither residential nor predominate	60/ >45	Large – very large
	> 55-60/ >40-45	Medium
	< 55/ <45	Small – very small

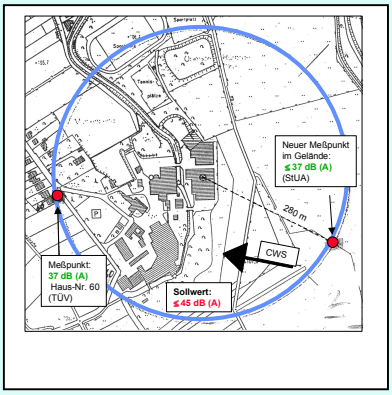
- Determination of rating sound levels (nighttime) on the basis of immission measurements at outdoor space points

Space points selected:

Point 1: Residential building	38 dB (A)
Point 2: Open field	≤ 38 dB (A)

⇨Classification of the environmental burden according to the immission guideline for this type of zone: **small**
(according to the authorities, the rating sound level (nightly limit) is < 45 dB (A))
Note on remaining uncertainties:
There are no reliable data regarding effects on the fauna

Fig. 1: Immission measurements at certain outdoor space points, year:1996



Step 2b: Consideration of other decision-making criteria	
In the future (revised version of the Technical Guideline on Noise), when several sources of noise exist simultaneously, it will be required to consider the magnitude of the effect potential of the enterprise that contributes to noise pollution	Unimportant to date
Step 2c: Assessment of the environmental relevance	
– Taking into account the results of Steps 2a and 2b	**low**
Step 3: Overall evaluation and identification of the need for action [Chapter 3.4]	
• Overall evaluation of the environmental problem, considering the environmental burden caused by the effect potential of the enterprise • Classification of the need for action, considering the overall evaluation the enterprise's budget for construction and other purposes An enterprise may strive to reduce noise levels even when it meets the immission limits of the Technical Guideline on Noise (*TA Lärm, VDI 2058*) It should be taken into account that the draft of the revised version of the Technical Guideline on Noise provides for a consideration of the area's overall noise burden in assessments of potential negative effects of commercial facilities (whether they are subject to licensing or not). This means that the rating sound levels of a facility will not be analyzed in an isolated fashion, but rather in the context of the noise pollution created by other enterprises located in the vicinity.	⇨ Classification of the environmental problem based on the environmental relevance determined: **small** Need for action: **none at present**
Recommendations for the planning of future actions [Chapter 3.5]	
• Possibilities to reduce the effect potential of the enterprise - Sound-proofing of noise-emitting equipment, and other technical noise abatement measures - Optimization of on-site traffic	With regard to plans for building a biofilter installation, the enterprise and the relevant authority have agreed upon an rating sound level of 42 dB (A).
■ **Transfer of the results to Result sheet 1, Chapter 4 (cf. Appendix III)**	

No. 8: Environmental problem of acidification of the soil (regional level); e.g. paint factory

Step 1: Determination of the magnitude of the environmental impacts concerning the environmental problem of acidification of the soil [Chapter 3.2]

Step 1a: Determination of the effect potential of the enterprise

- Assignment of the environmental impacts of the enterprise Emissions of acidifying atmospheric pollutants

Direct environmental impacts

At the site:

- Nitrogen dioxide	1.22 t/a
- Sulphur dioxide	0.05 t/a
- Chlorohydrocarbon	0 t/a
- Fluorohydrocarbon	0 t/a

Transportation in the region:

- Nitrogen oxides	0.31 t/a
- Sulphur dioxide	0.03 t/a
- Chlorohydrocarbon	0 t/a
- Fluorohydrocarbon	0 t/a

Indirect environmental impacts

none

- Aggregation of the enterprise's environmental impacts to form the effect potential of the enterprise
  - Multiplication of the atmospheric pollutant loads by their equivalence factors, and addition to compute the effect potential of the enterprise [Equivalence factors ➔ Appendix IV.4, A.1]

Direct environmental impacts

At the site:	
- NO_2: 1.22 t/a x 0.70	= 0.85 t/a
- SO_2: 0.05 t/a x 1.00	= 0.05 t/a
Effect potential of the enterprise	= 0.90 t/a

Transportation:	
- NO_x: 0.31 t/a x 0.70	= 0.22 t/a
- SO_2: 0.03 t/a x 1.00	= 0.03 t/a
Effect potential of the enterprise	= 0.25 t/a

Total environmental impacts

Effect potential of the enterprise = 1.15 t/a

Step 1b: Determination of the effect potential of the reference area (example: administrative district as reference area)

- Assignment of the overall environmental impacts in the reference area
  [Data on the reference area ➔ Appendix IV.4, A.1]
- Aggregation of the environmental impacts to form the effect potential in the reference area
  - Multiplication of the atmospheric pollutant loads by their equivalence factors, and addition to compute the effect potential
    [Equivalence factors ➔ Appendix IV.4, A.1]

NO_2:	131,025 t/a	x 0.70 =	91,718	t/a
SO_2:	50,181 t/a	x 1.00 =	50,181	t/a
HCl:	1,335 t/a	x 0.88 =	1,175	t/a
HF:	115 t/a	x 1.60 =	184	t/a
NH_3:	608 t/a	x 1.88 =	1,143	t/a
Effect potential in the reference area			144,400	t/a

Step 1c: Determination of the specific contribution of the enterprise

- Division of the effect potential of the facility by the effect potential in the reference area

Site:	0.90 t/a : 144.400 t/a = 6.23×10^{-6}
Traffic:	0.25 t/a : 144.400 t/a = 1.73×10^{-6}
Total:	1.15 t/a : 144.400 t/a = 7.96×10^{-6}

Step 2: Assessment of the environmental relevance of the problem of acidification of the soil in the regional environment [Chapter 3.3]	
Step 2a: Determination of the environmental state	
▪ Compilation of selected data and information on the environmental state [see Appendix IV] Threshold values (critical loads) are exceeded by inputs of acidifying substances into forest soils in the reference area (radius of approx. 10 km around the site of the facility) [Evaluation matrix ➔ Appendix IV.2, B.8]	Threshold values are exceeded in almost all forest sections in the reference area ⇨ Classification of the environmental burden: **very large**
Step 2b: Consideration of other decision-making criteria	not applicable
Step 2c: Assessment of the environmental relevance	
– Taking into account the results of Steps 2a and 2b	**very high**
Step 3: Overall evaluation and identification of the need for action [Chapter 3.4]	
▪ **Transfer of the results of Steps 1 and 2 to Result sheet 2, Chapter 4 (cf. Appendix III)**	

No. 17: Environmental problem of the greenhouse effect (global level); e.g. metal processing plant

Step 1: Determination of the magnitude of the environmental impacts concerning the environmental problem of the greenhouse effect [Chapter 3.2]

Step 1a: Determination of the effect potential of the enterprise

■ Assignment of the environmental impacts of the enterprise

Emissions of gases with relevance to the global climate

Direct environmental impacts
At the site:
- Carbon dioxide 1,896 t/a

Indirect environmental impacts
Waste incineration:
- Carbon dioxide 1,286 t/a

Generation of electricity:
- Carbon dioxide 30,728 t/a
- Methane 73 t/a
- Nitrous oxide 1.4 t/a

Prior production of fuels for the facility:
- Carbon dioxide 152 t/a
- Methane 2 t/a

Indirect environmental impacts (total)
- Carbon dioxide 32,116 t/a
- Methane 75 t/a
- Nitrous oxide 1.4 t/a

Environmental impacts (direct + indirect
- Carbon dioxide 34,012 t/a
- Methane 75 t/a
- Nitrous oxide 1.4 t/a

▪ Aggregation of the enterprise's environmental impacts to form the effect potential of the enterprise

- Multiplication of the atmospheric pollutant loads by their equivalence factors, and addition to compute the effect potential of the enterprise
[Equivalence factors ➔ Appendix IV.4, A.3]

Direct environmental impacts:
- CO_2: 1,896 t/a x 1 = 1,896 t/a
Effect potential of the enterprise = 1,896 t/a

Indirect environmental impacts
- CO_2: 32,116 t/a x 1 = 32,116 t/a
- CH_4: 75 t/a x 21 = 1,575 t/a
- N_2O: 1.4 t/a x310 = 434 t/a
Effect potential of the enterprise = 34,125 t/a

Total environmental impacts:
- CO_2: 34.012 t/a x 1 = 34,012 t/a
- CH_4: 75 t/a x 21 = 1,575 t/a
- N_2O: 1.4 t/a x 310 = 434 t/a
Effect potential of the enterprise **36,021 t/a**

Step 1b: Determination of the effect potential of the reference area (example: Germany as reference area)

▪ Assignment of the overall environmental impacts in the reference area
[Data on the reference area ➔ Appendix V]

▪ Aggregation of the environmental impacts to form the effect potential in the reference area

Multiplication of the atmospheric pollutant loads by their equivalence factors, and addition to compute the effect potential
[Equivalence factors ➔ Appendix IV.4, A.3]

CO_2:	926,600 kt/a	x 1	=926,600	kt/a
CH_4:	5,194 kt/a	x 21	=109,074	kt/a
N_2O:	226 kt/a	x 310	= 70,060	kt/a
CF_4:	0.278 kt/a	x 6,500	= 1,807	kt/a
C_2F_6:	0.036 kt/a	x 9,200	= 331	kt/a
SF_6:	0.204 kt/a	x23.900	= 4,876	kt/a

Effect potential in the reference area **1,112,748 kt/a**

Step 1c: Determination of the specific contribution of the enterprise	
▪ Division of the effect potential of the facility by the effect potential in the reference area	Direct:: 1,896 t/a **:** 1,112,748 kt/a = 1.70×10^{-6} Indirect: 34,125 t/a **:** 1,112,748 kt/a = 3.07×10^{-5} Total: 36,021 t/a : 1,112,748 kt/a = 3.24×10^{-5}
Step 2: Assessment of the environmental relevance of the problem of the greenhouse effect [Chapter 3.3]	
Step 2a: Determination of the environmental state	
▪ Compilation of selected data and information on the environmental state [see Appendix V]	
- Global change in mean temperature	**- Global change in mean temperature:** 0.3 to 0.6°C since the end of the 19th century → Global rise in sea level: 10 to 25 cm since the end of the 19th century
- Atmospheric concentrations (CO_2, CH_4, N_2O)	**- Atmospheric concentrations of CO_2, CH_4, N_2O:** CO_2: pre-industrial period: 280 ppm 1994: 358 ppm CH_4: pre-industrial period: 0.7 ppm 1994: 1.72 ppm CO_2: pre-industrial period: 275 ppb 1994: 312 ppb
▪ Evaluation criteria / assessment based upon environmental action targets and environmental quality targets [see Appendix V]	– Expected increase in global temperature by the year 2100, at present emission trends: +2.0°C (range 1 to 3.5°C)
- Limiting the global rise in mean temperature to +0.1°C per decade	
Step 2b: Consideration of other decision-making criteria	
- Reversibility	- Once initiated, a change in climate is very probably irreversible
- Geographical extension	- Global level
Step 2c: Assessment of the environmental relevance	
– Taking into account the results of Steps 2a and 2b	**very high**
Step 3: Overall evaluation and identification of the need for action [Chapter 3.4]	
▪ **Transfer of the results of Steps 1 and 2 to Result sheet 3, Chapter 4 (cf. Appendix III)**	

Step 3a: Overall evaluation, and identifying the crucial problem areas

The specific contributions of the enterprise and the relevance of certain environmental problems should be entered into the corresponding result sheets [Appendix III, Result sheet no. 1-3] to provide an overview of the overall results.

At the local level it is easy to identify the enterprise's crucial problems areas. To assess environmental problems with regional or national/global significance, however, it is necessary to compare the specific contribution of the enterprise [→ Step 1c] with the relevance of the problem [→ Step 2c].

First of all, the environmental problem areas should be sorted for this purpose: Environmental problem areas having a very high environmental relevance should be at the top of the list, and those having low or no relevance at the bottom [Appendix III, Result sheets no. 2 and 3]. The direct and indirect environmental impacts of the enterprise are then entered into the sheets.

Result sheet no. 1: Local reference level (various practical examples)				
→ Transfer of the results from the processing sheets				
Environmental problem	**Effect potential of the facility**	**Environmental relevance of the problem**	**Need for action**	**Remarks**
Local reference level (cf. practical examples 1 to 5)				
Disturbance due to noise (e.g. paint factory)	-	Low	No need for action at present	Sound-proofing measures when installing a biofilter facility to meet the rating sound level agreed upon with the authorities
Disturbance due to odors (e.g. chemical plant)	-	Low	No acute need for action	Regular and systematic controls of the emission of odors
Visual disturbance (e.g. food processing plant)	-	Low	No acute need for action	Plantings of greenery, and changes in the pavements in the course of maintenance or renovation of the installations
Warming of the surface (e.g. food processing plant)	-	High	Possibilities for action are small at present	See above
Fire hazard (e.g. paint factory)	-	Low	Because of the location, the hazard potential is high in the case of accidents,	Construction, technological and organizational measures, plus precautionary gradual reduction of substances constituting a fire hazard or groundwater hazard (see processing sheet for details)
		but there is no acute need for action regarding the enterprise's measures to minimize risk		
Potential threats to the groundwater (e.g. paint factory)	-	Low	See above	

Result sheet no. 2: Regional reference level (e.g. thermal power plant)

→ Transfer of the results from Processing sheets; in addition, see Appraisal of the need for action

Regional reference level

Note:

Examples are selected from various economic sectors, to better illustrate the computations for different environmental problems. A thermal power plant is used as example of an overall assessment at the regional reference level. Therefore, the numerical examples used in the processing sheets will sometimes deviate from those given here.

Environmental problem area	**Specific contribution of the enterprise (Step 1)** **Absolute figures, and relative contribution based on the highest specific contribution of the enterprise (set to equal 1)**						**Environmental relevance in the region (Step 2) (due to the sum of environmental impacts)**
	At the site		Indirect		Total		
	absolute	relative	absolute	relative	absolute	relative	
Terrestrial ecotoxicity: NO_2	$2.69 \bullet 10^{-3}$	0.62	0	0	$2.69 \bullet 10^{-3}$	0.62	Very high
Eutrophication of the soil	$2.66 \bullet 10^{-3}$	0.61	0	0	$2.66 \bullet 10^{-3}$	0.61	Very high
Acidification of the soil	$1.87 \bullet 10^{-3}$	0.43	0	0	$2.00 \bullet 10^{-3}$	0.43	Very high
Destruction of natural habitats	$6.43 \bullet 10^{-4}$	0.15	$4.54 \bullet 10^{-8}$	< 0.01	$6.43 \bullet 10^{-4}$	0.15	Very high
Summer smog	$4.26 \bullet 10^{-4}$	0.10	0	0	$4.26 \bullet 10^{-4}$	0.10	Very high
Toxicity to humans: air-borne dust	$6.97 \bullet 10^{-4}$	0.16	0	0	$6.97 \bullet 10^{-4}$	0.16	High - very high
Eutrophication of water bodies	$1.30 \bullet 10^{-3}$	0.30	$3.61 \bullet 10^{-5}$	0.01	$1.33 \bullet 10^{-3}$	0.31	High
Toxicity to humans: NO_2	$2.69 \bullet 10^{-3}$	0.62	0	0	$2.69 \bullet 10^{-3}$	0.62	Medium to high
Terrestrial ecotoxicity: SO_2	$4.72 \bullet 10^{-4}$	0.11	0	0	$4.72 \bullet 10^{-4}$	0.11	Medium to high
Aquatic ecotoxicity: copper	$3.1 \bullet 10^{-3}$	0.71	0		$3.1 \bullet 10^{-3}$	0.71	Medium
Aquatic ecotoxicity: zinc	$4.9 \bullet 10^{-4}$	0.11	0		$4.9 \bullet 10^{-4}$	0.11	Medium
Aquatic ecotoxicity: mercury	$5.3 \bullet 10^{-4}$	0.12	0		$5.3 \bullet 10^{-4}$	0.12	Medium
Resource utilization, water: river-bank filtrate	$4.37 \bullet 10^{-3}$	1.00	$3.86 \bullet 10^{-6}$	< 0.01	$4.37 \bullet 10^{-3}$	1.00	Low
Aquatic ecotoxicity: AOX	$4.3 \bullet 10^{-4}$	0.10	0	0	$4.3 \bullet 10^{-4}$	0.10	Low
Toxicity to humans: SO_2	$4.72 \bullet 10^{-4}$	0.11	0	0	$4.72 \bullet 10^{-4}$	0.11	Low to very low
Aquatic ecotoxicity: cadmium	$2.3 \bullet 10^{-4}$	0.05	0	0	$2.3 \bullet 10^{-4}$	0.05	Low
Aquatic ecotoxicity: lead	$1.0 \bullet 10^{-4}$	0.02	0	0	$1.0 \bullet 10^{-4}$	0.02	Low
Toxicity to humans: CO	$1.22 \bullet 10^{-4}$	0.03	0	0	$1.22 \bullet 10^{-4}$	0.03	Very low
Resource utilization, water: groundwater and spring water	0	0	$2.29 \bullet 10^{-6}$	< 0.01	$2.29 \bullet 10^{-6}$	0.001	Low
Acidification of water bodies	$1.87 \bullet 10^{-3}$	0.43	0	0	$2.00 \bullet 10^{-3}$	0.43	None

→ Transfer of the results to Evaluation sheet no. 1a: problem groups, Appendix III

A graphical representation of the results of this evaluation can help to interpret the data, particularly with respect to the specific contribution of the enterprise [→ Fig. 4.2, example of a thermal power plant, and Fig. 4.3, example of a paint factory]. → Appendix III, Annex A to Result sheet no. 2 and 3 offers help in drawing such a graph.

Fig. 4.2: Comparison between the specific contributions of an enterprise and the relevance of existing environmental problems in a region, exemplified by a thermal power plant

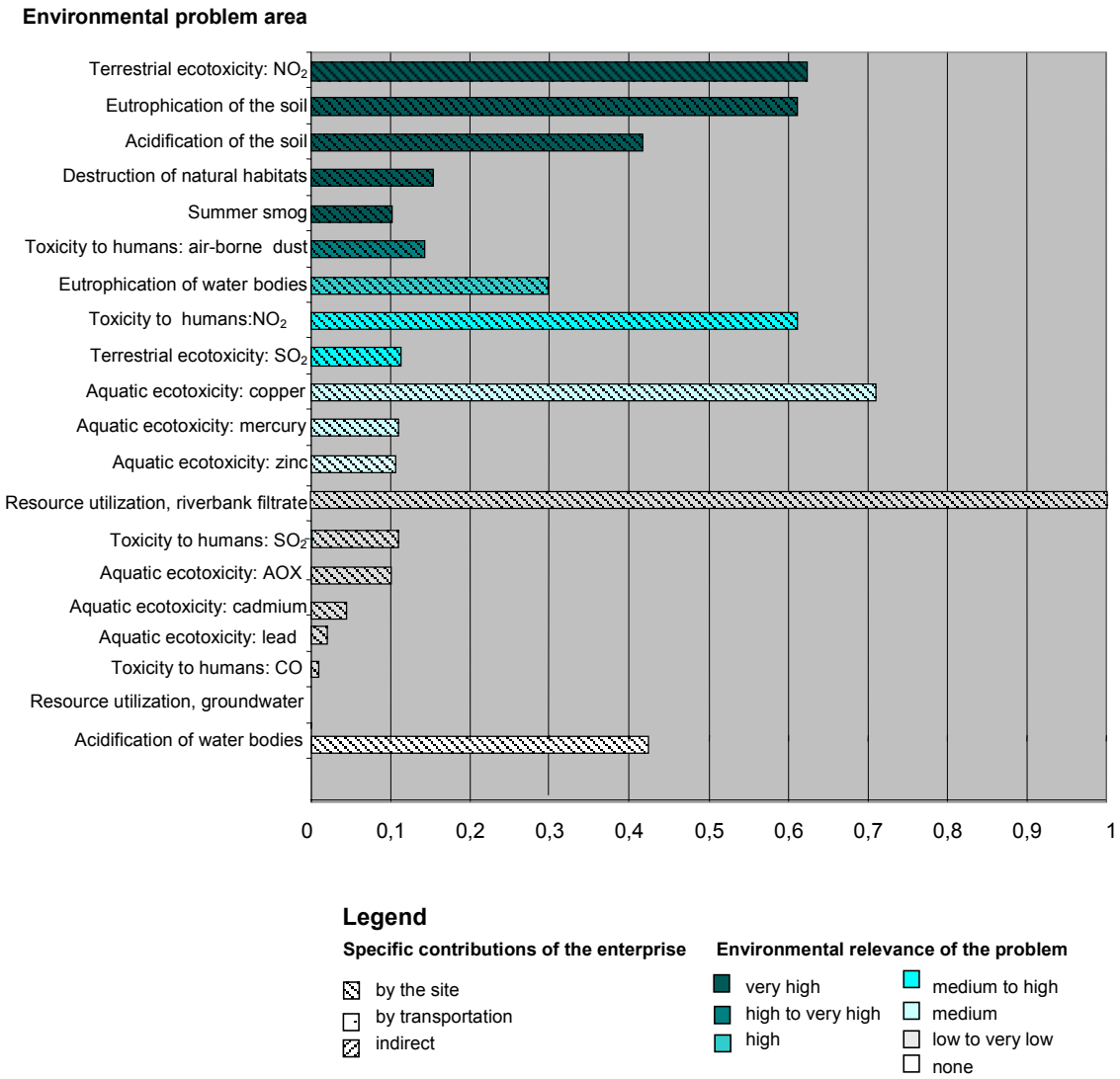
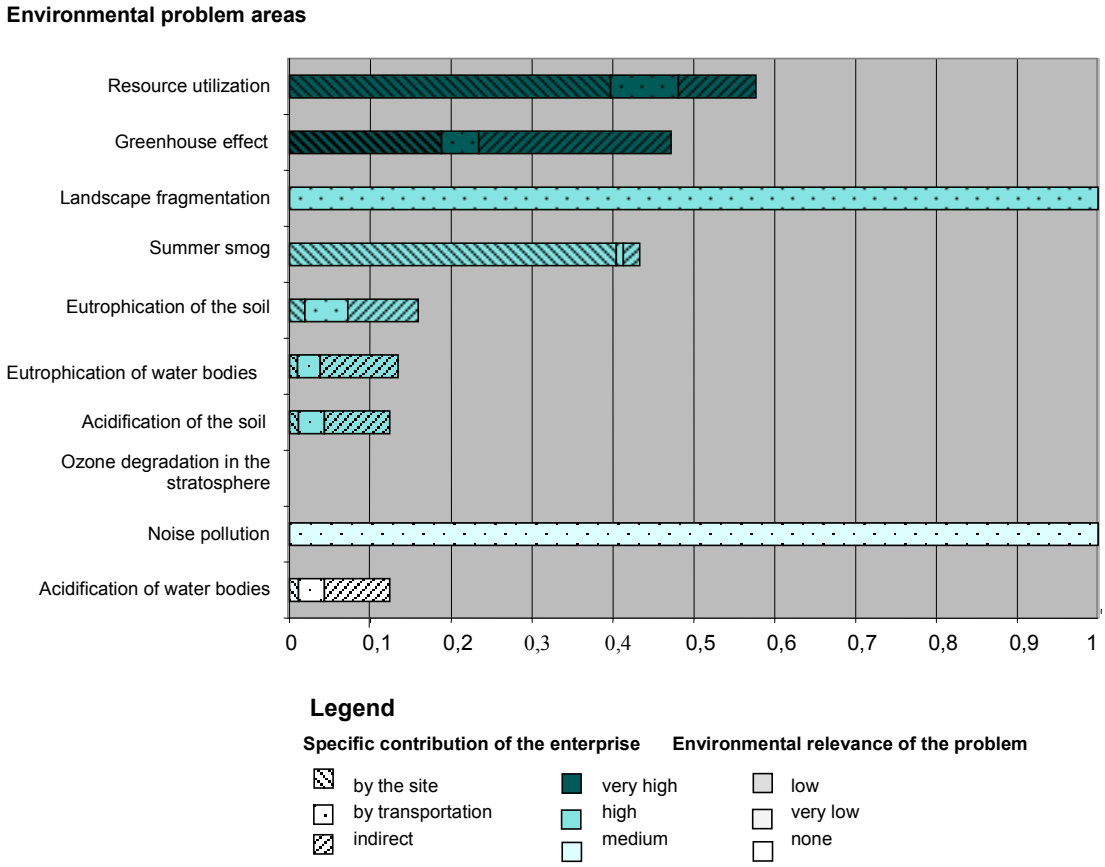


Fig. 4.3: Comparison between the specific contributions of an enterprise and the relevance of existing environmental problems at the national/global reference level, exemplified by a paint factory



The results of Result sheet no. 2 and 3 can then be transferred to Evaluation sheet no. 1a and 1b [Appendix III]. Assignment of the environmental problems according to the problem groups in Table 3.3 (Chapter 3.4) will help to identify the crucial problems [→ example of a thermal power plant, regional reference level, and example of a paint factory, national reference level]. The environmental effects that have been estimated qualitatively (e.g. the evaluation of materials and products) is also included at this point [→ Appendix III, Data assessment sheet no. 1, Annex 1d].

Every environmental problem area where both, the environmental relevance and the specific contribution of the enterprise, are high or very high, is classified in Group 1a. The need for action is obvious in these cases. Group 1b includes those environmental problem areas with very high environmental relevance, but no more than a medium contribution of the enterprise.

Environmental problem areas where the specific contribution of the enterprise and the environmental relevance are both low or very low are not regarded as crucial problem areas. This presupposes, however, that applicable legal limits are being met.

The concept is illustrated in the following two examples, based on Evaluation sheet no. 1a at the regional reference level for a thermal power plant, and Evaluation sheet no. 1b at the national/global level for a paint factory.

The example of the thermal power plant in Fig. 4.2 shows that the direct environmental impacts are the principal ones in its case. This is due to the fact that the power plant uses few external services.

The analysis in Fig. 4.3 of the paint factory at the national/global level shows that the enterprise's transportation activities and the indirect environmental impacts (energy consumption, waste disposal etc.) have an importance similar to its direct impacts. Transportation activity significantly contributes to existing environmental problems.

Step 3b: Appraisal of the need for action

The final task in the environmental assessment consists in determining the measures to be undertaken by a business or organization. The appropriate combinations of environmental relevance and specific contributions of the enterprise are demonstrated in Evaluation sheets 1a and 1b. The general need for action for each combination can be assessed from the right-hand column of → Table 3.3 in Chapter 3.4. Besides the rank of each environmental problem area, the decision needs to consider additional criteria. Evaluation sheets 2a and 2b [→ Appendix III] provide assistance in that regard.

In the case of the thermal power plant at the regional reference level, the result is the following:

Measures undertaken in the past are already effective at present in those areas identified as crucial problems, so that the enterprise can maintain the present focus of its action plan. Numerous resource conservation measures have already been undertaken with respect to the environmental problem "resource utilization water / riverbank filtrate", which is always very high in this economic sector (e.g. recirculation of non-potable water). For reasons of sustainability, the enterprise will continue to strive towards an economic use of resources, as far as the circumstances (technological feasibility) permit.

The need for action is small in the case of some of the other environmental problems at the regional level (e.g., toxicity to humans / CO, resource utilization of groundwater), where the specific contributions of the enterprise and the environmental relevance are low. Legal limits are being met.

In the case of the paint factory, the enterprise's environmental target of "reducing the specific energy consumption" may be cited as an example. This goal helps to minimize the environmental problems "greenhouse effect" and "resource utilization". The target is correct, since both problem areas are recognized as crucial. The enterprise will continue to focus on solutions to the transportation problem, even though the possibilities to reduce traffic are limited when it comes to distribution of the products.

Glossary

Equivalence factor

A weighting factor designed to compensate for differences in effect potential between different environmental impacts in an →impact category. Equivalence factors are relative quantities based on a reference substance (e.g. emissions of greenhouse gases are expressed in terms of CO_2 equivalents, depending on their effect potential with respect to global warming). Equivalence factors have until now been used most often in life cycle assessments of products.

Inputs and outputs of a business or an organization

Flows of matter and energy that enter or leave an enterprise.

Environmental balance of a business or an organization

Compilation and quantification of →inputs and outputs. →Environmental aspects.

Critical Level

→Effect thresholds.

Critical Load

→Effect thresholds.

Basic principles of sustainability

These include the following aspects:

Regeneration: Renewable natural resources (e.g. wood, or fish stocks) should in the long run only be exploited within the limits of their regeneration capacity, because they will otherwise be lost to future generations.

Substitution: Non-renewable natural resources such as minerals and fossil fuels should only be exploited to the extent that their functions can be replaced by other materials or fuels.

Adaptability: The release of matter and energy should in the long run not exceed the adaptability of ecosystems such as the climate, the forests, and the oceans.

ISO Norms 14.000 ff.

International guidelines for the evaluation of environmental management systems. According to ISO Norm 14001, businesses and other organizations may obtain a certification of their environmental management system. ISO Norms that have been adopted by the German Institute of Norms (*Deutsches Institut für Normung*, DIN) are termed ISO/DIN Norms.

Local Agenda 21

The UN Conference on the Environment and Development (UNCED) held in Rio de Janeiro in 1992 adopted an action program, termed Agenda 21, designed to initiate environmentally sustainable development. Chapter 28 calls upon local communities throughout the world to adapt the Agenda 21 framework to the local level (Local Agenda 21).

No Effect Level

→Effect thresholds.

Ecological carrying capacity

The capacity of an ecosystem's regulatory mechanisms to maintain ecological stability in spite of the factors acting upon the system (→environmental impacts). This capacity is limited, however. The ecological carrying capacity can break down when certain capacity or tolerance limits are exceeded (→environmental effects).

Ecosystem

The manifold interactions between biotic factors (the living environment including plants, animals, and humans) and abiotic factors (non-living components of the environment such as the climate, water, or earth).

Ecotoxicity

Effects of contaminants on entire →ecosystems, or on their individual biological components.

Phytoplankton

A general term for algae belonging to the plankton, i.e. the community of organisms that live suspended in the water column, which have little or no independent mobility.

Environmental aspects

The term "environmentally relevant aspect" ("environmental aspect" for short) is used in the ISO/DIN Norms 14000 ff. It is defined as that part of an organization's activities, products or services which may interact with the environment (in a narrow or broad sense), and concerns both, the management sector (e.g. energy management, energy savings, and selection of energy sources) as well as the operating sector (e.g. consumption of energy, electricity and heat) of a business or an organization. It is thus distinct from the narrower term →environmental impacts.

Environmental effects

The environmental effects in an ecosystem basically represent its reaction to the environmental impacts that impinge upon it. The environmental effects of a business or an organization thus include any modification of the environment that is partly or wholly due to the enterprise's activities, products or services (→ISO 14000 ff.).

Environmental impacts

Environmental impacts are those aspects of activities, products and services which exert a direct influence on the environment. An example of an environmental impact are the atmospheric emissions resulting from the generation of electricity (the consumption of energy in the form of electricity does not itself constitute an environmental impact, even though it results in environmental impacts).

Environmental action targets

Environmental action targets are quantitative goals with respect to a certain environmental burden, and they are addressed at the causative agent, usually the source of an emission. They are established according to socio-economic sectors. Environmental action targets describe the steps required to attain a certain state or property of the environment that has been set as an →environmental quality target (e.g. an 83% reduction of sulphur emissions in Germany by the year 2000, and an 87% reduction by 2005, based on 1980 levels). Thus, environmental action targets are a measure of concrete operational steps.

Environmental indicators

Data compiled by a business or organization to quantify issues related to environmental protection. They include →environmental performance indicators and →environmental state indicators.

Environmental performance indicators provide information on the environmental services of a business or organization. Besides data which relate to the operational sector of an enterprise (e.g. pollutant emissions in tons per year), there exist so-called management performance indicators to describe the achievements of environmental management (e.g. number of complaints about noise or odor pollution per year, number of environmental training sessions).

Environmental state indicators, on the other hand, are data on the state of the environment (→indicators of the state of the environment) – compiled by the enterprise, or provided by government agencies – that are used in the enterprise's environmental dataset (pollutant concentrations in the atmosphere or in the soil etc.).

Environmental quality targets

Environmental quality targets describe a desired state in the environment. They include both, scientific and social-ethical components. Environmental quality targets are set with regard to the necessities of humans and/or the environment, applying

to specific elements or environmental media, and thus relate to immissions or effects.

Environmental relevance

The term "environmental relevance" in the manual denotes the significance of an environmental problem within a given scope. The relevance of an environmental problem depends on geographical characteristics, as well as on the burden created by the totality of polluters.

The activities, products and services of a business or an organization may be environmentally relevant if they interact with the environment in a broad or narrow sense (→environmental aspects, environmental impacts) and if they lead to modifications of the environment (→environmental effects).

Environmental state indicators

Specific data that provide information on the state of the environment at the local, regional, national or global level. Environmental indicators are usually set by government agencies, non-governmental organizations, and scientific institutions (e.g. pollution levels in water bodies, air quality).

Environmental problem area

All environmental impacts making a significant contribution to an environmental problem are classified by environmental problem area (→impact category).

Environmental objectives

This term encompasses the environmental action targets based on the causes of pollution, and the environmental quality targets based on immissions and effects. In addition, an enterprise can set its own environmental objectives as instruments of its environmental management system.

Utility companies

Companies that provide services for businesses and organizations, such as supplying energy or water, or the removal and treatment of wastes and waste water.

Prior and subsequent production stages

Processes in the life cycle of goods and services taking place before or after the enterprise's own activities. Prior processes include the extraction of raw materials from the natural environment and the production of unfinished materials, and subsequent processes include any further processing, use and disposal of the products.

Impact factors

Variables describing the type of impacts by which a business or organization exerts an influence on its environment.

Impact category

The term "impact category" is used in the ISO Norm series 14000 ff., particularly in ISO 14040. Impact categories correspond to presently relevant environmental problem areas. An impact category encompasses all environmental impacts contributing significantly to an environmental problem (e.g. the impact category "greenhouse effect" includes all gases of relevance to the climate).

Effect thresholds (No Effect Level, Critical Levels, Critical Loads)

Thresholds set according to scientific criteria; sub-threshold concentrations or inputs of a substance have no effect. Thresholds for direct impact pathways (e.g. the atmospheric pathway) are termed Critical Levels, and those for indirect impact pathways are termed Critical Loads (e.g. the pathway atmosphere-soil).

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