Development of a sustainable Waste Management Concept for Khanty-Mansiysk, Russia

Annex III

- Development of Scenarios -

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ABBREVIATIONS AND UNITS

BMU	The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CDM	Clean Development Mechanism
CIS	Commonwealth of Independence
Eol	End-of-life
GDP	Gross Domestic Product
H&CW	Household & Commercial Waste
KM municipality	Khanty-Mansiysk municipality
KMAO-Ugra	Khanty-Mansiysk Autonomous Okrug – Ugra
M DEP	Municipal Road – Operational Enterprise
MBT	Mechanical-Biological Treatment plant
MSW	Municipal Solid Waste
PE	Polyethylene
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinylchloride
RDF	Refuse Derived Fuel
SPP	Sorting and Processing Plant
SWM	Solid Waste Management
UBA	German Federal Environment Agency
WM	Waste Management
WMC	Waste Management Concept

kg c^{-1} a^{-1}	Kilogrammes per capita and year
kg c^{-1} w^{-1}	Kilogrammes per capita and week
Mg	Megagram (1Mg = 1,000kg = 1 ton)
Mg a^{-1}	Megagrammes per year
KJ kg^{-1}	Kilojoule per Kilogrammes

1 INTRODUCTION

The main task within the development of a sustainable **W**aste **M**anagement **C**oncept (WMC) is the development and identification of feasible scenarios considering the given waste management infrastructure, quantity and quality of future waste streams, state-of-the-art technology, superior policy frameworks as well as ecological, social and economic limits. The identified scenarios should also reflect the range of disposal options in the investigation area.

In the further cause of the WMC development the range of possible waste management alternatives has to be focused by intensive discussions with the responsible representatives of the administration in Khanty-Mansiysk on the prepared scenarios and an evaluation based on social, ecological and economic considerations; i.e. environmental impacts, socio-economic aspects, and financial feasibility of the scenarios were examined.

Based on data from the waste analyses, water content analyses, research of infrastructure, market analysis etc. which are summarised in the ***status-quo report*** (July 2011) within the project “Development of a sustainable Waste Management Concept for Khanty-Mansiysk, Russia”, three waste treatment options were developed and proposed. The evaluation of the possible solutions was carried out by an adjusted list of evaluation criteria and assessment benchmarks.

Benchmarks for the assessment of waste management scenarios have to be jointly agreed with the political decision makers and they depend mainly on strategic considerations. At that point of the WMC development the importance of disposal security, environmental protection, economic and social aspects has to be defined. This adjustment process took place in several meetings between the responsible administration of Khanty-Mansiysk and the German project team from September until November 2011.

During intensive discussions on the best fitting waste management scenario further questions on the feasibility occurred. Among them are the feasibility of biological treatment under severe climate conditions in Siberia, cost-savings achieved by recycling activities or market opportunities for secondary fuels (RDF). For that reason further investigations were initiated (see ***Annex IV*** to the Final Report; Development of a sustainable Waste Management Concept (WMC) for Khanty-Mansiysk, Russia).

Finally, the representatives of the local administration of Khanty-Mansiysk have to decide which waste treatment option will be developed further to the final waste management concept for Khanty-Mansiysk municipality. This report represents the basis for the decision.

2 DEVELOPMENT OF SCENARIOS

The project step development of scenarios has to be considered differentiated. At the first step waste management options, from collection to final disposal, were selected according to the quality and quantity of relevant waste streams and the existing waste management infrastructure. The pre-selection of waste treatment technologies should be done unaffected from strategic or political priorities. During the further development process the local framework conditions, strategic considerations and political requirements has to be integrated and the scenarios has to be refined respectively.

2.1 Technical and organisational considerations

For the drafting of basic scenarios the current amounts of relevant waste streams, their composition, their physico-chemical properties (especially water content, heating value, total organic carbon, chlorine content, heavy metals concentrations etc.) and their estimated values for the next 15 to 25 years are needed. From these data, potentials for incineration, energy recovery, biological treatment and recycling were derived. The data on waste amounts and composition and on water content were analysed during two Solid Waste Analysis (SWA) campaigns in February and June 2011. The heating value was estimated on the basis of the results of the SWA, including secondary data from literature (calorific values). Based on data about the development of population and economy growth, the amount and composition of waste was forecasted until 2024. A detail description of the quantity and quality of relevant waste streams and their estimated figures until 2024 as well as the description of the existing waste management infrastructure is given in ***Annex I*** (Status-quo report) to the final report.

2.1.1 Municipal solid waste composition and waste amount of Khanty-Mansiysk

The total annual amount of municipal solid waste (MSW) in Khanty-Mansiysk was calculated as 25,800 Mg a^{-1}. The household waste consists mainly of four categories:

- organic (34%)
- glass (13%)
- plastic (12%) and
- paper (11%).

They comprise 69% of the total waste composition in Khanty-Mansiysk. Almost all other fractions (except fines and metals) are under 5.0% (see figure 1).

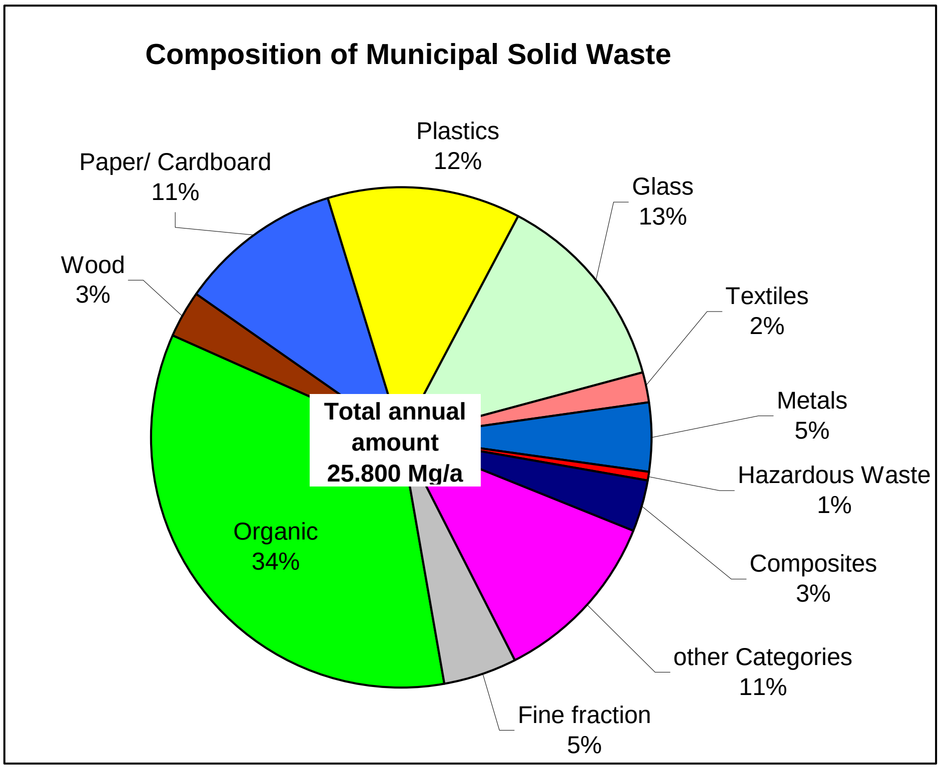

figure 1: Composition of municipal solid waste in Khanty-Mansiysk in 2011

2.1.2 Potential of MSW for different waste treatment options

Based on the composition of municipal solid waste in Khanty-Mansiysk, the potential for each key treatment option such as recycling, incineration and biological treatment was identified and the results are summarised in the next chapters.

Potential for waste incineration

The heating value of municipal solid waste in Khanty-Mansiysk was calculated at 7,000 kJ/kg (see figure 2). Furthermore, the amount of waste which is to be disposed on of the landfill can be reduced from 25.800 Mg $a^{-1}$of municipal solid waste to 8,500 Mg a^{-1} of ash; i.e. inert waste (see figure 2).

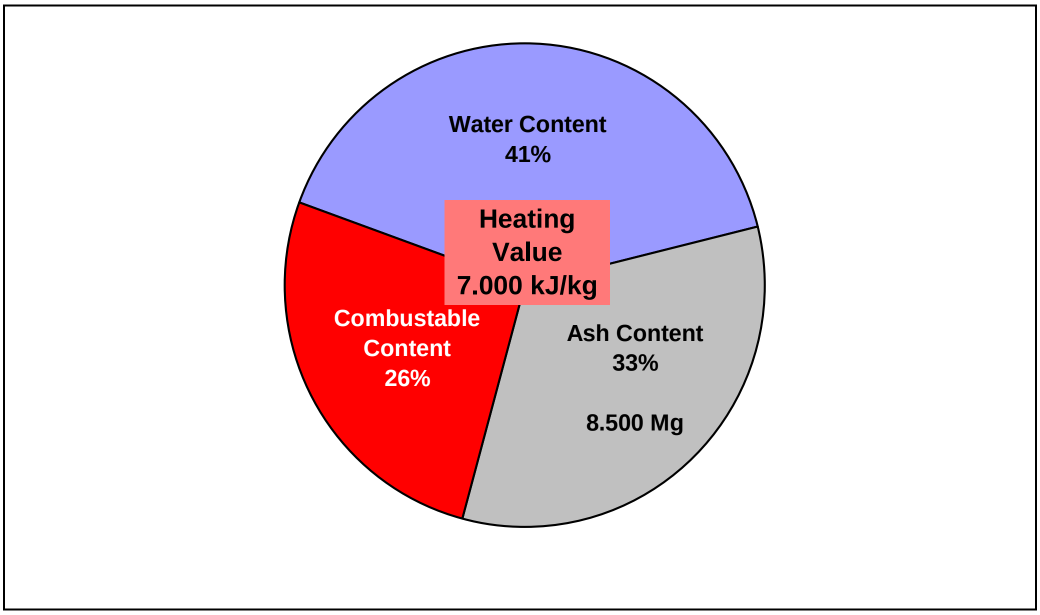

figure 2: Heating value and relevant parameters of municipal solid waste in Khanty-Mansiysk in 2011

Potential for co-incineration from burnable fractions

In the next step, only the burnable fractions of municipal solid waste of Khanty-Mansiysk were combined. In total, 36% or 9.300 Mg a^{-1} of 25.800 Mg a^{-1} demonstrate a burnable quality (see figure 3).

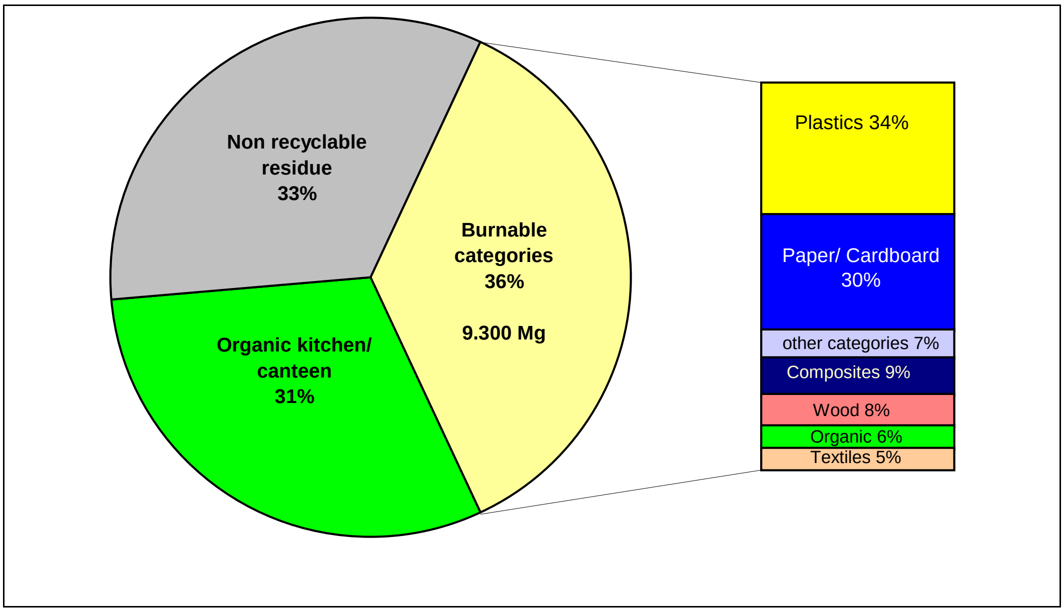

figure 3: Potential for incineration from municipal solid waste in KM municipality

The following figure shows that the heating value is increasing when only the burnable fractions are used in an incineration treatment plant. Based on the lower amount of waste which will be burned, the ash content is decreasing. However, the combustible content is increasing (see figure 4).

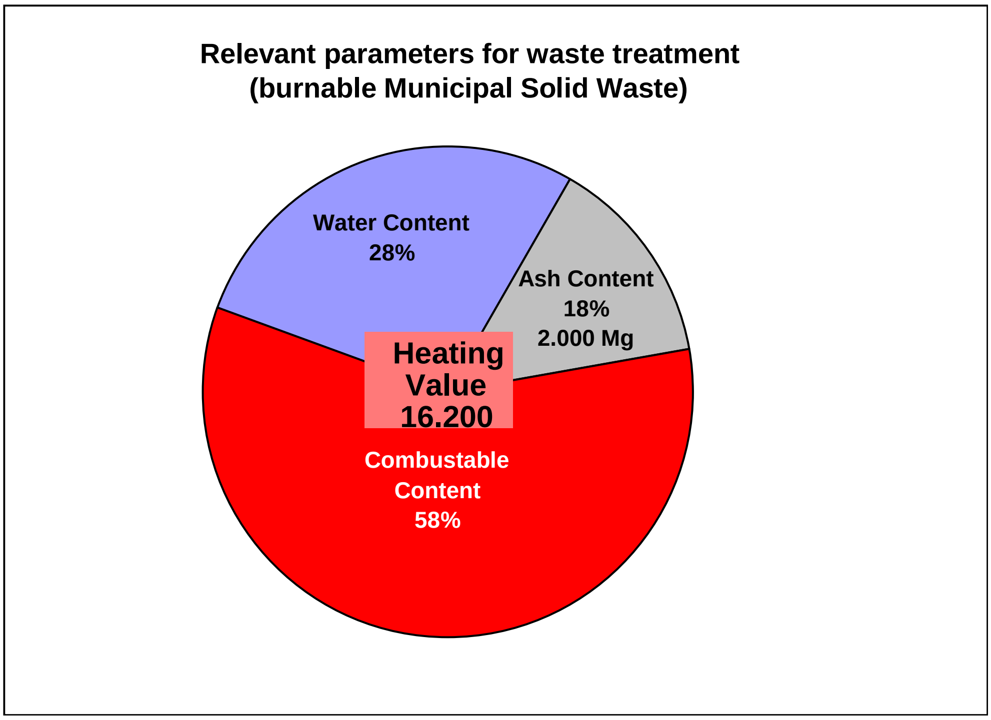

figure 4: Heating value and relevant parameters of combined burnable fraction within the municipal solid waste in KM municipality

Potential of recycling

For assessing the potential of recycling, the waste fractions with a potential for recycling are combined and three different waste material flows could be identified (see figure 5):

1. potential for recycling,
2. potential for composting and
3. non recyclable residue (no potential for recycling and/ or composting).

47% of the entire municipal solid waste or 11.900 Mg a^{-1} of 25.800 Mg a^{-1} show a potential for recycling. Fractions which can mainly be used for recycling are: paper, glass, metals and plastic (see figure 5).

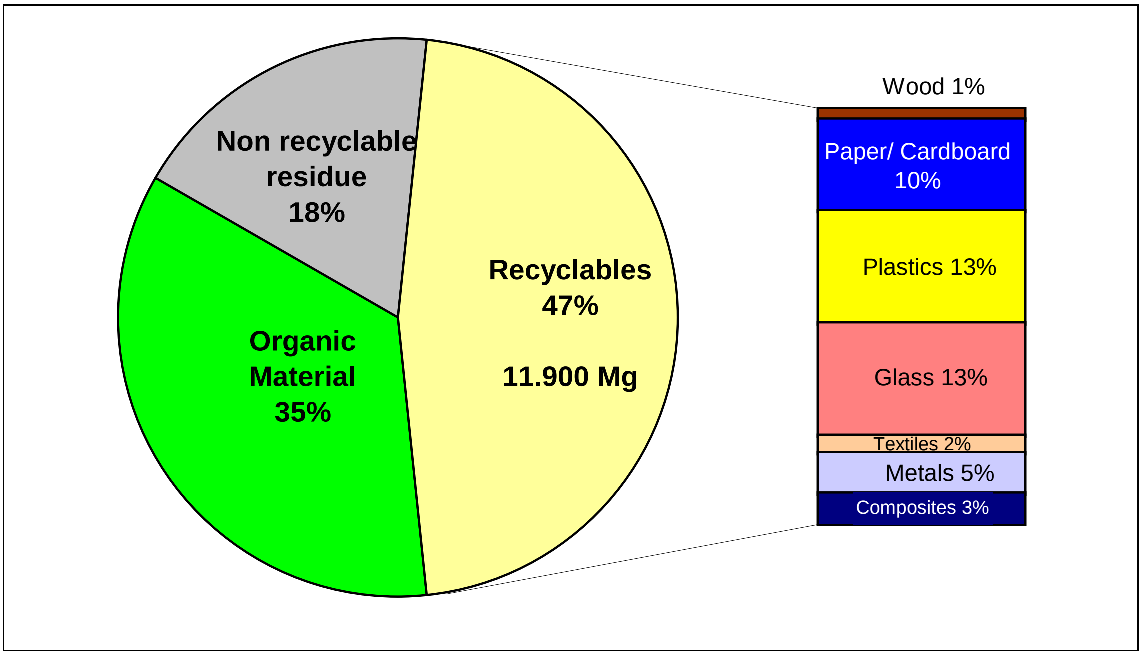

figure 5: : Recycling potential from municipal solid waste in KM municipality

The following figure demonstrates another combination (see figure 6). The fractions for composting were combined. Not only the organic (35%) also paper (10%) and wood (1%) can be composted. In total, 46% of the municipal waste or 11.850 Mg a^{-1} of the 25.800Mg a^{-1} can be treated.

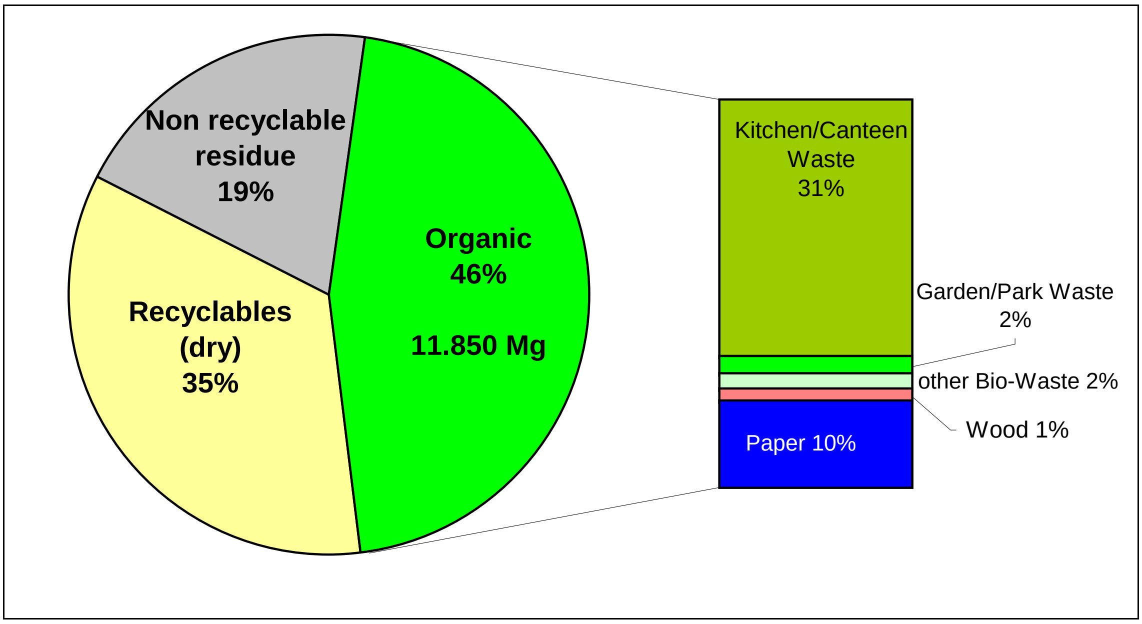

figure 6: Potential for biological treatment from municipal solid waste in KM municipality

2.1.3 Prognosis of waste amount and composition

The successful planning of a sustainable waste management concept depends on the prediction accuracy of solid waste generation. Prognoses are essential for selecting a suitable type of future waste disposal, for the size of waste treatment plants as well as for the decision of utilisation of waste such as recycling.

According to the calculations done by ARGUS e. V., the generation of H&CW will increase from 25,800 Mg a^{-1} in 2010 to 50,500 Mg a^{-1} in 2024 in Khanty-Mansiysk; i.e. the amount of household waste including commercial waste, will be doubled in the next 14 years (see table 1). Furthermore, it can also be expected that the amount of bulky waste, construction & demolition waste, street cleaning waste, waste from veterinary clinics (including dead animals from livestock farms and pets) and end-of-life tyres will increase significantly.

table 1: Prognosis of municipal waste until 2024 [Mg a^{-1}]

Waste types	2010	2012	2014	2016	2018	2020	2022	2024
Household Waste & Commercial Waste	25.784,9	28.737,3	32.027,8	35.351,1	39.019,1	43.067,7	46.617,9	50.460,7
Household Waste	21.917,2	24.426,7	27.223,7	30.048,4	33.166,2	36.607,6	39.625,2	42.891,6
Commercial Waste (similar to household waste)	3.867,7	4.310,6	4.804,2	5.302,7	5.852,9	6.460,2	6.992,7	7.569,1
Bulky waste & construction & demolition waste	3.410,0	3.800,5	4.235,6	4.675,1	5.160,2	5.695,6	6.165,1	6.673,3
Sum of other waste types	1.921,8	2.141,8	2.387,0	2.634,7	2.908,1	3.209,8	3.474,4	3.760,8
Medical waste	180,0	200,6	223,6	246,8	272,4	300,6	325,4	352,3
Street cleaning residues and waste from litter bins, Garden and park waste, market waste	1.428,0	1.591,5	1.773,7	1.957,8	2.160,9	2.385,1	2.581,8	2.794,6
Veterinary medicine waste	0,8	0,8	0,9	1,0	1,1	1,3	1,4	1,5
End-of-life tyres	313,0	348,8	388,8	429,1	473,6	522,8	565,9	612,5
Total	**31.116,7**	**34.679,6**	**38.650,5**	**42.660,9**	**47.087,4**	**51.973,2**	**56.257,4**	**60.894,9**

Prognosis of waste amount disposed on of the landfill for selected treatment options

One key aim of the future waste management in Khanty-Mansiysk is the reduction of the waste amount disposed of on the landfill. Therefore, the waste amount for landfilling and the waste amount used for recovery were estimated. The basis is the waste amount predicted for 2024.

The results, given in table 2, clearly demonstrate that the scenario “Deposition” includes the highest amount of waste for landfilling. 100% or 50,460 Mg a^{-1} of household & commercial waste were disposed of on the landfill. The waste treatment options “incineration” and “separate collection and MBT” imply the highest reduction of waste for disposal. Through the option incineration the amount of waste is reduced from 50,460 Mg a^{-1} to 14,870 Mg a^{-1}. The waste amount of 50,460 Mg a^{-1} can be decreased to 23,180 Mg a^{-1} through the option “separate collection and MBT”.

However, the results also show that disposal of waste is necessary for each scenario; i.e. a landfill site has to be implemented in the urban waste management concept.

table 2: Prognosis of waste amount disposed on of the landfill for selected treatment options

Waste treatment options		type of disposal	2010 [Mg/a]	2014 [Mg/a]	2018 [Mg/a]	2024 [Mg/a]
Deposition			25.785	32.028	39.019	50.461
MSW incineration	1	landfill	7.598	9.437	11.497	14.869
		recovery	18.187	22.591	27.522	35.592
RDF co-incineration	2	landfill	17.798	22.107	26.933	34.831
		recovery	7.987	9.920	12.086	15.630
Composting	3	landfill	18.336	22.776	27.748	35.884
		recovery	7.449	9.252	11.272	14.577
Anaerobic digestion	4	landfill	18.336	22.776	27.748	35.884
		recovery	7.449	9.252	11.272	14.577
MBT	5	landfill	13.547	16.826	20.499	26.510
		recovery	12.238	15.201	18.520	23.950
Separate collection	6	landfill	19.846	24.651	30.032	38.839
		recovery	5.939	7.376	8.987	11.622
Separate collection + MBT	7	landfill	11.845	14.713	17.924	23.180
		recovery	13.940	17.315	21.095	27.280

[1] 80 % of metals recycled from slag
[2] 80% of burnable fractions are separated for RDF, 80 % of metals recycled
[3] 60% of organic is separat collected, 55% are recycled
[4] 60% of organic is separat collected, 55% are recycled
[5] 80% of metals and glass are recycled,75% of burnable fractions are recovered
[6] 60% of recyclables are separat collected, 50% are recycled
[7] 60% of recyclables are separat collected, 50% are recycled, 80% of remaining metals and glass are recycled,75% of remaining burnable fractions are recovered

2.1.4 Existing waste management infrastructure

The current waste management system in Khanty-Mansiysk consists of collecting the waste daily through a pick-up system with waste containers on public streets and disposing of the entire waste generated on the landfill. There are no recycling facilities. Only few and small companies exist to carry out the collection of different waste streams (scrap branch and paper branch).

The distance from Khanty-Mansiysk to other towns is more than 200 km; i.e. the distances between Khanty-Mansiysk and waste facilities of other towns are long, a temporary use of these waste facilities would be neither economically nor environmentally practical. Although Khanty-Mansiysk is well integrated into the federal roads and navigable water systems as well as its local roads being in a good condition, Khanty-Mansiysk is relatively isolated compared to other towns in KMAO-Ugra such as Surgut and Neftyuganz. As Khanty-Mansiysk is not connected to the railway, waste transport via railway system would require transportation to the railway stations in Surgut (300 km) or in Py'tach (250 km). However, for long distance shipments transportation via water should be considered.

The baseline scenario describes the current waste management system implemented in Khanty-Mansiysk supplemented by imperative measures to protect human health and the environment from uncontrolled waste disposal. These measures are related to hazardous and industrial waste, which should be separately collected and treated.

The municipal solid waste (MSW, mainly from private households and commerce) is collected by a pick-up system as mixed residual waste from the waste generators in the receptacles provided for this purpose. In Khanty-Mansiysk more than 2.000 mobile waste containers (most of them has a volume of about 500 litres) are picked up daily by refuse collection vehicles, which are of rear end loaded. Pick-up systems for hospital waste, industrial waste and other hazardous waste should be implemented as soon as possible. It is of great importance to keep hazardous materials separately from non-hazardous municipal solid waste. The industry has to be obliged to keep hazardous waste separately and to order a waste management company for disposal or implement self-delivery systems for hazardous waste. For hazardous waste from private households and small businesses collection points or assembly centres (recycling centres) should be implemented.

At current stage no waste treatment in KM, besides some metal scratch sampling and dealing, is implemented. The Municipal Solid Waste from private households and small businesses is brought without any further treatment to the landfill site.

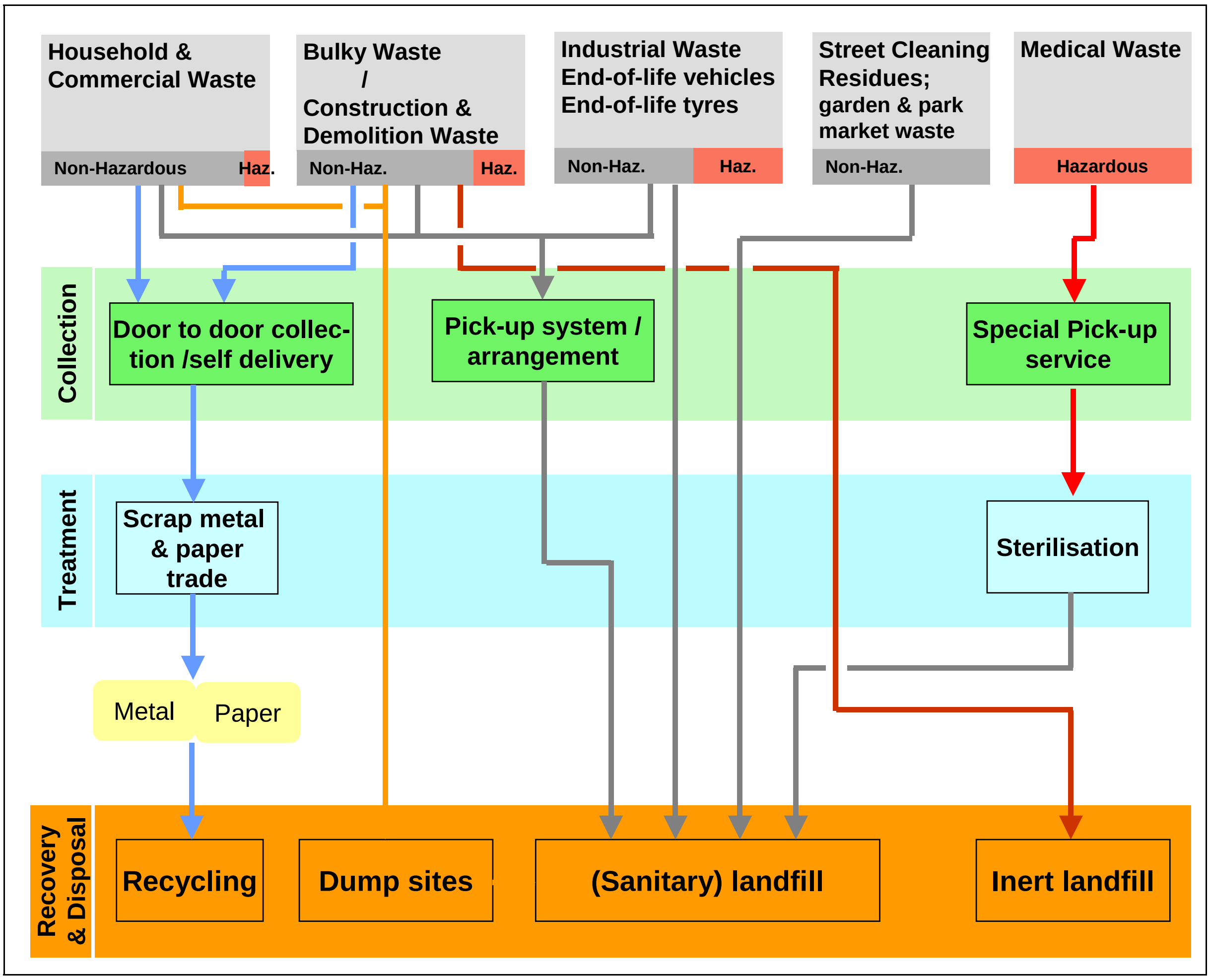

figure 7: Existing waste management situation (baseline scenario)

From figure 7 it can be seen, that some types of hazardous waste (hospital waste) are already collected and treated (sterilised), on the other hand hazardous waste from industry and private households/small businesses is still disposed together with the MSW. For these hazardous waste types neither collection schemes nor treatment/ disposal options are implemented. In the short term specific protected areas on the landfill site should be prepared to deposit these hazardous substances until a final and sustainable solution is realised.

2.1.5 Other aspects to be considered for scenario development

Khanty-Mansiysk shows severe climate conditions, i.e. very long and cold winters and short and hot summer periods. Especially biological waste treatment methods are affected by these severe climate conditions. It can be assumed, that the treatment facilities has to be encapsulated and heated during winter times. This will case additional waste treatment costs.

For implementing a recycling scenario, knowledge about the current recycling market is essential. Therefore, a market analysis was implemented during the research for the status-quo-report. The results of the market analysis can be summarised as following:

- There is hardly any separate collection of recyclables at source in Khanty-Mansiysk. Paper/ Cardboards (mainly cardboards) are collected in Khanty-Mansiysk from different shops and offices.
- There are no recycling facilities besides of a scrap branch.
- The next paper mill for paper-recycling is located in Yekaterinburg (1.500 km).
- The next glass melt factory is situated in Surgut (250 km).
- There are no plastic recycling activities in the region.
- There is no collection system for electric and electronic equipment (WEEE) in the region.
- There is no collection system for used textiles.
- There is no infrastructure for compost used as fertiliser.

The existence of a recycling industry and respectively a market for recycling products is a crucial prerequisite for implementing recycling strategies for Khanty-Mansiysk municipality. Currently, the recycling market hardly exists and is mainly implemented by very small companies. This fact has to be taken account for developing the waste management concept.

The research regarding waste legislation demonstrates that the waste legislation in Russia places fundamental requirements on waste management. Nevertheless, these requirements have not been implemented yet. Many laws were developed at the time of the Soviet Union and do not correspond with the European standard. Finally, it can be stated, that there is no specific waste legislation which regulates responsibilities, management, environmental standards and the inspection and control. The waste management finance system is oriented on the operation cost of flats and an increase depends on the national income system. Furthermore, the legislation doesn’t include incentives to reduce waste.

2.1.6 Summary

It can be stated that the organic fraction is the biggest waste category in Khanty-Mansiysk with 34%. Nevertheless, the municipal solid waste is burnable without supplementary firing and a heating value of 7,000 kJ/kg. It can be expected, that the heating value will increase due to consumer habits (more Paper and plastics, less organic and glass). Furthermore, 36% of the MSW is suitable for the production of RDF. During the exclusive incineration of the 36% suitable fractions, an increase from 7,000 KJ/kg to 16,200 kJ/kg can be assumed. The composition of the waste also shows a high potential for recycling and/ or composting as 46% of MSW is recyclable or 47% of MSW is compostable.

In conclusion, incineration demonstrates the best deposition security and reduction rate of deposition on the one hand. On the other, separate collection and MBT is most flexible, fitting best to the regional waste management concept and is most environmentally friendly. Otherwise, for an implementation of this scenario, a recycling marked has to be established. However, for all waste treatment scenarios, the current waste management infrastructure such as collection system, landfill site etc. has to be optimised.

2.2 Basic waste management options

Waste management covers the complete process from waste generation to final recovery or disposal. At least three stages on the life cycle of Municipal Solid Waste (MSW) can be distinguished.

(1) waste collection & transport,

(2) waste treatment and

(3) recovery & disposal.

(1) Waste collection can be implemented by a pick-up system, which means, that the waste is collected at each estate, or by a drop-off system, which means, that the citizens will bring the waste to a certain place (e.g. bring banks or recycling centres). There are various systems for waste collection. By using pick-up systems the waste from households and commerce is collected at source. That means, the waste is collected from bins or containers by specific vehicles at each estate (private households or commercial facilities). By drop-off systems, containers are placed on public streets and the generator of waste brings the waste to those containers or bring banks.

(2) Waste treatment means, that the waste is processed mechanically, biologically or thermal before the residues are brought to recycling facilities or to a landfill site. Waste treatment serves several purposes: reduction of landfill volume, reduction of carbon emission, reduction of human pathogens, production of recyclables, and production of energy.

(3) At the third stage the waste will be recovered (recycled or converted into energy) or disposed. For recycling of materials such as metals, glass, paper, plastics etc. a functioning recycling industry has to be established.

The table 3 gives an overview on basic waste management options. A detailed description of waste management technologies is given in ***Annex II*** (Description of waste management technologies) to the final report.

table 3: Overview on waste management options

Process	Sub area	Specification
Waste collection & transport	Pick-up system Drop-off system	Mobile waste container & rear-end vehicle Bring bank & collection vehicle with crane
Waste treatment	Mechanical Mechanical-biological Biological Physical Thermal	Comminution, sorting, classification, ... Composting, anaerobic digestion Neutralisation, Sterilisation, Pyrolysis Incineration
Recovery & disposal	Deposition Recovery	Inert landfill, sanitary landfill, hazardous landfill Recycling of metals, paper, glass, plastics Energy recovery by co-incineration

Considering the technical/ organisational parameters as well as the amount and composition of the relevant waste streams, following basic waste management scenarios were proposed.

Scenario 1: Recycling

The recycling scenario is based on the information, that nearly 60% of the collected waste in KM municipality are recyclables which can be recovered by separate collection and waste treatment measures.

The municipal solid waste (MSW, mainly from private households and commerce) is collected by a pick-up system as mixed residual waste from the waste generators in the receptacles provided for this purpose. These can be mobile waste containers of different types or sizes, which are picked up by one of the different types of refuse collection vehicles, which are in most cases of rear end loaded. In the drop-off system, accumulated waste amounts are taken by the waste generator to a central location and are being dropped there into specially set up containers. Collection vehicles need to go to this central sites only to pick up the waste. Collecting waste in this way is most suitable for source separated recyclables. Successful locations are sites with a high visibility and a high frequency of customer traffic such as near shopping centres or parking areas. Special care must be given to the regular cleansing of these sites.

The recyclables has to be treated further in a mechanical sorting plant.

The waste is then treated by mechanical and biological processes in a mechanical-biological treatment facility (refer to figure 8) with the goal of reducing overall weight and volume and achieve the stabilisation of the waste before its final disposal. During the treatment recyclable materials (mainly metals) and a combustible fraction are separated from the remaining waste stream by mechanical processes, while biological processes (either rotting processes or anaerobic digestion) achieve the drying and degradation of the waste material and thus its deactivation. Additionally glass, paper and plastics can be collected separately by drop-off systems and pre-treated (sorting).

The recovered recyclables can be further processed by the respective recycling industries, the combustible fraction used for energy recovery and the stabilized residues deposited in a sanitary landfill (refer to slide 11). From figure 8 can be seen which waste management options has to be implemented.

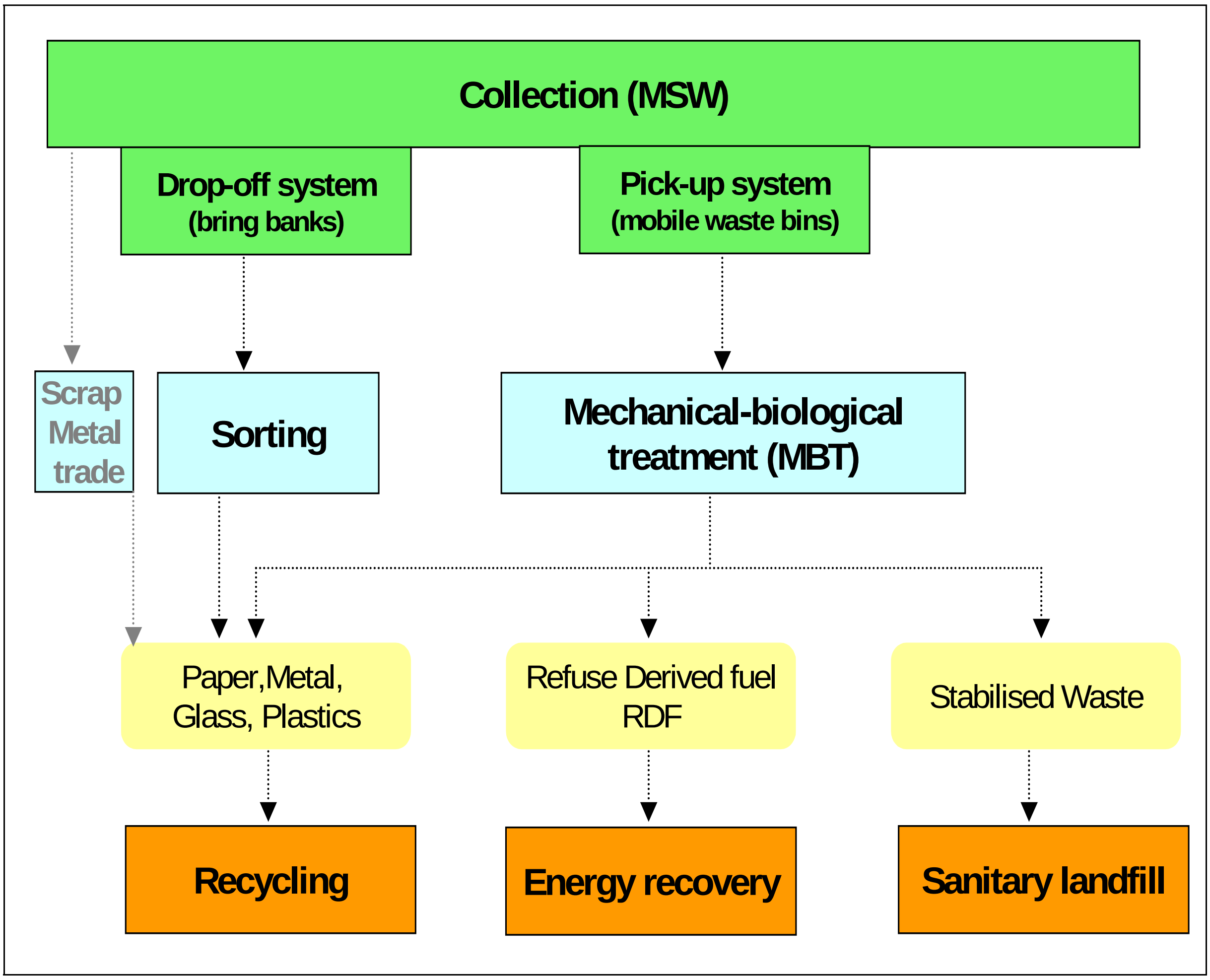

figure 8: Scenario 1 (Recycling option)

Scenario 2: Biological treatment

Main fraction of the MSW in KM is organic. Therefore it was obvious to investigate a treatment option which is based on biological processes (anaerobic digestion as well as composting). (refer to figure 8)

The municipal solid waste (MSW, mainly from private households and commerce) is collected as mixed residual waste from the waste generators in the receptacles provided for this purpose. These can be mobile waste containers of different types or sizes, which are picked up by one of the different types of refuse collection vehicles, which are in most cases of rear end loaded. The separate collection for bio-waste has to be implemented accordingly to the collection of MSW as a pick-up system. This means that each household is equipped with two containers, one for MSW and one for bio-waste. Larger amounts of biodegradable waste that arise for example in form of green cuttings, garden or kitchen waste can also be collected and transported to the biological treatment plant.

The bio-waste has to be pre-treated in a mechanical sorting plant. A mechanical pre-treatment before the composting is obligatory and can further improve the quality of the input but not ensure the generation of a waste fraction from mixed household waste that is suitable to meet high standard composting requirements. Mechanical pre-treatment can consist of

- Separation of foreign matter and contaminants
- Size reduction
- Metal separation

Mechanical pre-treatment can also be used to attain the optimum structure and C/N ratio in the composting input by combining various organic wastes. For example, leaves (high in carbon, low in nitrogen) can be blended with food waste (high in nitrogen) to balance the C/N ratio. In this way, emissions of ammonia can be minimized right from the beginning of the rotting. Bulking agents can be added to the raw material if it lacks the structure to maintain adequate porosity within the compost pile. Typical particle sizes should be approximately 1 cm for windrow composting with forced aeration composting and 5 cm in case of passive aeration methods.

The material for composting is set up in windrows of different size and shape. Bucket or wheel loaders are normally used to build high windrows whereas turning machines create low and wide windrows. Windrows are set up with heights between 1.80 to 3.00 m depending on the shape. Most common are windrows with a triangular, trapezoid and flat-top profile. The composting process differs in dependence from the applied method of aeration whereas static and dynamic models are distinguished. Depending on the applied model about 10-60 weeks are needed for the entire rotting process to be completed. The residual waste, collected by a pick-up system is brought untreated to the landfill site.

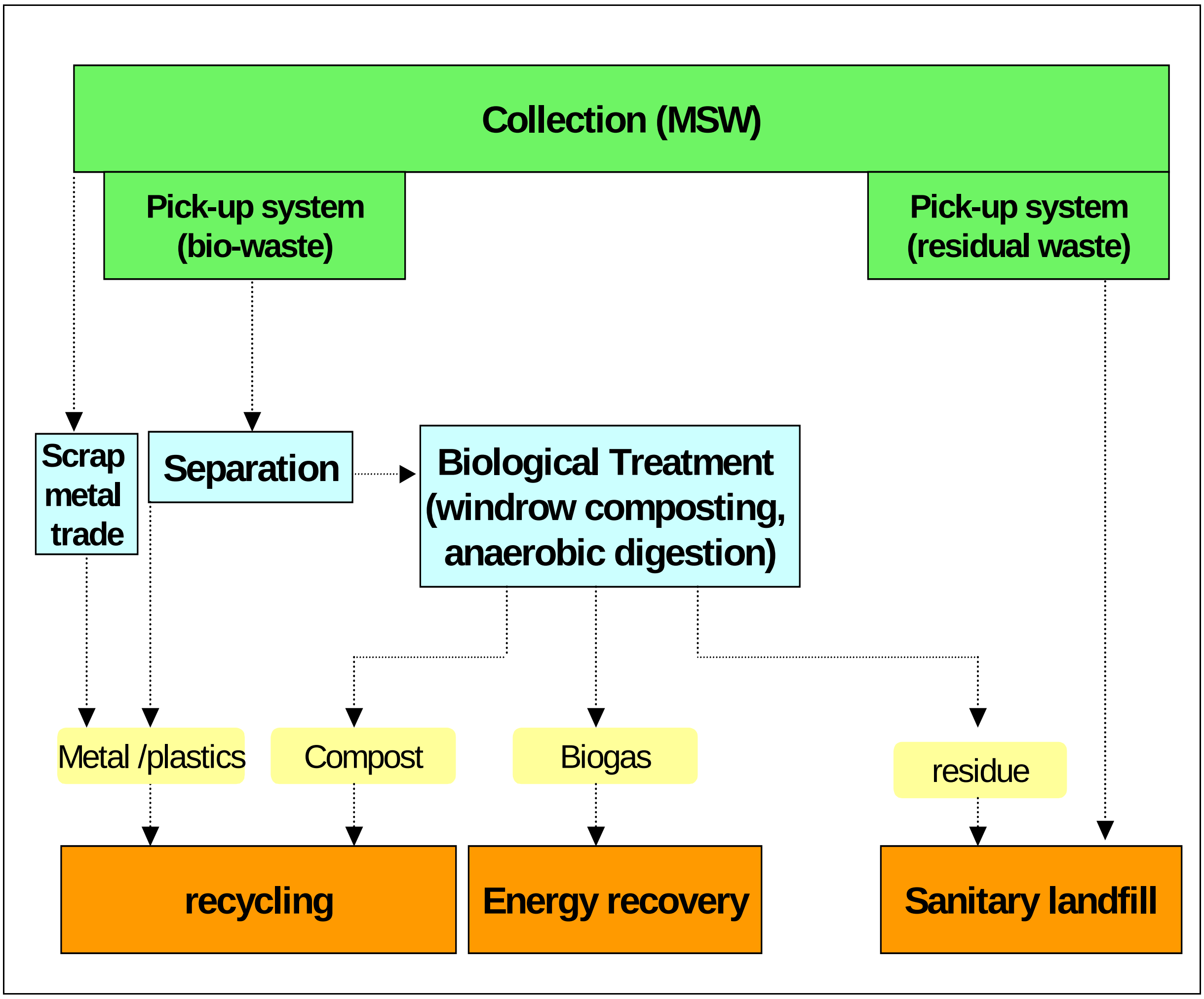

figure 9: Scenario 2 (Biological treatment option)

Scenario 3: Incineration

The analysis of waste composition and properties shows clearly, that the MSW in KM is also suitable for incineration. The heating value was determined by 7.000 MJ per Mg. This is sufficient for self burning.

The municipal solid waste (MSW, mainly from private households and commerce) is collected as mixed residual waste from the waste generators in the receptacles provided for this purpose. These can be mobile waste containers of different types or sizes, which are picked up by one of the different types of refuse collection vehicles, which are in most cases of rear end loaded. The separate collection by using a drop-off system can be implemented as described in scenario 1.

The waste is treated thermally in a waste incinerator. The incineration process aims at reducing the waste volume and risk potential through oxidation and mineralization, offering at the same time the opportunity of energy recovery (both energy and thermal). Various technologies for waste incineration are available; frequently used technology is the grate combustion as shown in slide 10. All technologies require installations for flue gas cleaning in order to ensure environmental protection standards to be met.

Waste incineration is especially recommendable for places where large and steady amounts of waste of varying composition need to be treated and users for the generated energy are existing (whereby the latter renders the incineration process to be economically more efficient). Also rather high investments must be considered. Metals can be recovered for recycling from the ashes, the generated slag deposited at sanitary landfills (refer to slide 11) whereas fly ashes and filter dust may have to go to hazardous landfills. Additionally glass, paper and plastics can be collected separately by drop-off systems and pre-treated (sorting). The recovered recyclables can be further processed by the respective recycling industries.

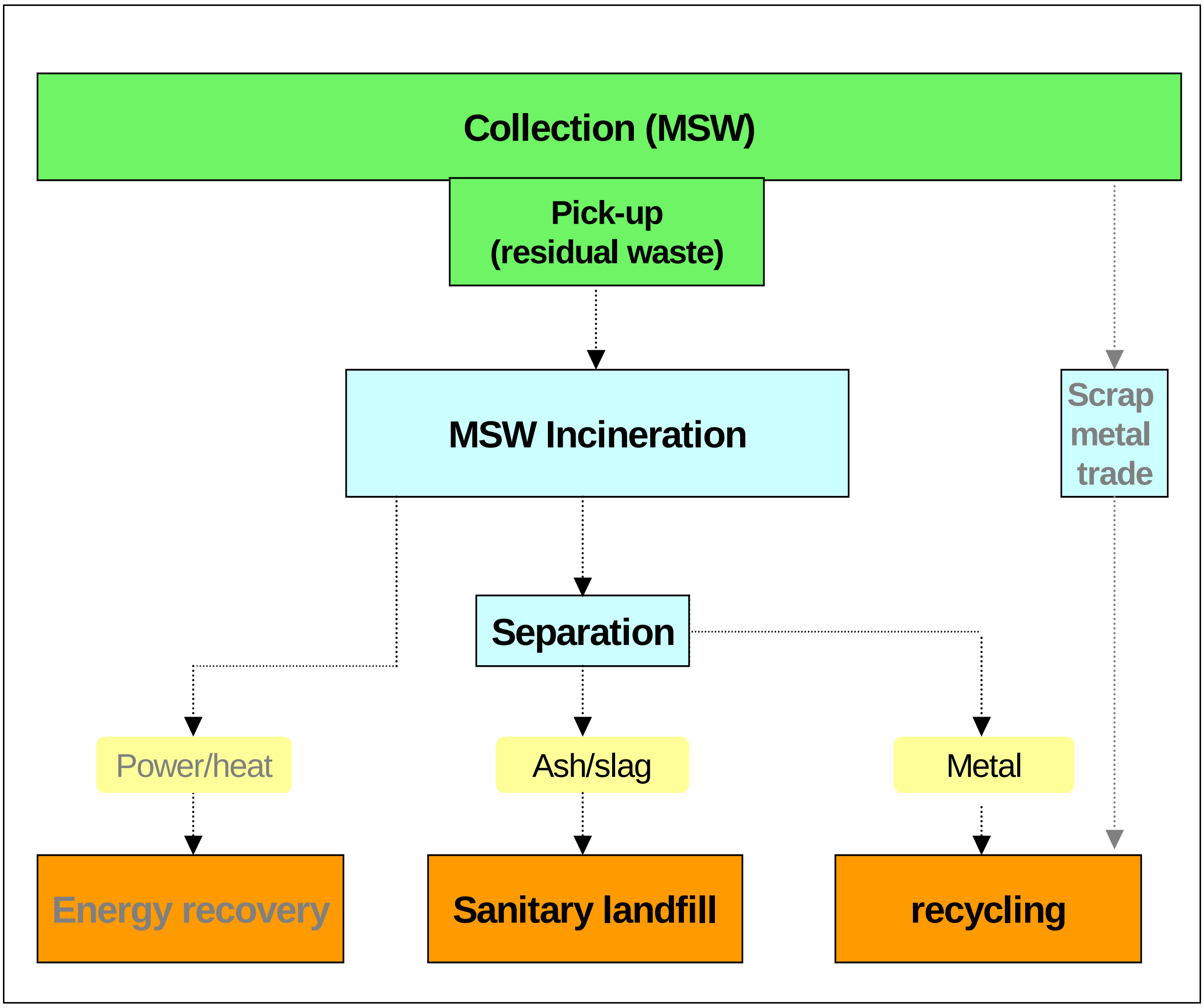

figure 10: Scenario 3 (Incineration)

2.3 Strategic/ political considerations (refinement of the basic scenarios)

In order to refine the proposed basic waste treatment options and to come to a final best fitting solution, the basic scenarios have to run through strategic considerations.

A strategy is a plan of action designed to achieve a particular goal. In this context, the goal is to develop and to implement a waste management system covering all stages of the waste flow from generation over segregation at source, collection, separation, pre-treatment to recovery / recycling and disposal. Proper waste management is a very high contribution to environmental protection (soil, air, water, and urban environment), resource protection and climate protection.[1]

Strategy in the case of an Integrated Strategy on Waste Management means to

- analyse the general situation of waste management in an investigation area,
- identify the needs and possible obstacles to reach the goal and
- define linking legal (order and control, economic incentives), administrative, communicative, and voluntary instruments.

Waste prevention is a necessary special aspect of proper waste management needing different specific considerations (strong link to product, consumption and industry policy).

Each strategy is prior determined by the overall objectives:

- Protection of human resources, nature and environment
- Waste disposal security
- Financial sustainability and cost efficiency
- Resource efficiency
- Social sustainability

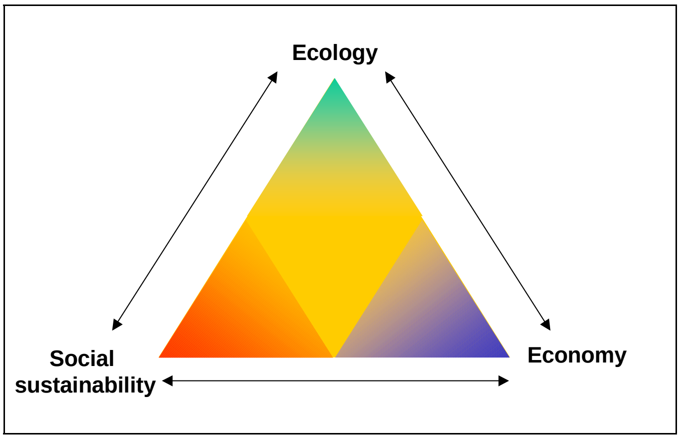

figure 11: Balance of influencing aspects

[1] The need to curb natural resources depletion increases the demand to minimize waste generation. Many countries are therefore faced with the necessity to initiate a process of transformation from the conventional (cheap) scheme of waste disposal through simple dumping or landfilling towards the (pretentious) gradual implementation of a closed loop management of their wastes.

The challenge is, to reach a balance between ecology, economy and social sustainability. The figure 11 shows the relationships between the influencing aspects.

Starting from the overall objectives specific or strategic goals have to be defined for each area of interest:

2.3.1 Ecology

Waste production along the entire life cycle of material and product flows cause sanitation problems and/ or environmental pollution. Industrialised societies and modern life style have an increasing consumption of products with hazardous substances. Therefore waste management has to cover the entire life cycle of materials/ products from resource extraction to final disposal including the monitoring of transportation and environmental pollution from waste treatment and recycling processes. Following strategic goals in the field of environmental protection can be identified:

- Introduction of waste prevention measures
  (deposit systems, innovative production, …)
- Implementation of environmental standards
  (e.g. landfill sealing systems for soil and ground water protection, flue gas purification at incineration plants, waste water treatment at mechanical-biological treatment plants etc.)
- Reduction targets for deposition
  (prohibition of deposition for recyclables & organic material, tax on deposition etc.)
- Determination of recycling targets
  (take-back obligation by producer, tax on resources etc.)
- Reduction of carbon emission
  (Methane gas collection, biological pre-treatment of waste, waste prevention, energy recovery from waste etc.)

Environmental indicators for selected treatment options

Environmental indicators such as deposition rate, energy recovery rate, recycling rate and carbon emission production also play an important role while developing a sustainable waste management concept (see table 4).

The data in table 4 demonstrates, that the scenario „Deposition“ shows the highest negative environmental impact as there is no reduction of the waste amount with a 100% deposition rate and it produces the highest carbon emission with 17,879 Mg CO_2-eq[2].

Regarding the deposition rate, the option “MSW incineration” shows the lowest deposition rate; i.e. the fewest amount of MSW is to be disposed on of the landfill. However, this option does not include an energy recovery or recycling rate and it produces more carbon emission than all others scenarios, except the scenario “Deposition”. In contrast to that result, the results of the scenario “MBT” presents there are energy recovery rate and recycling rate and the production of carbon emission is quite less, the deposition rate is low.

2 Note: The CO2-Equivalent (CO2-eq) or the Global warming potential indicates how much a set amount of a greenhouse gas causes the greenhouse effect/ global warming.

Regarding all mentioned indicators, the treatment option “Separate collection + MBT” demonstrates the lowest environmental impacts; a very small deposition rate, a high recycling rate and the lowest production of carbon emission with 613 Mg CO_2-eq.

table 4: Environmental indicators for selected treatment options based on the amount of MSW for KM municipality

Waste treatment options	Deposition rate	Energy recovery rate	Recycling rate	Carbon emission reduction [8]
Deposition	100%	-	-	17.879 t CO2 Eq
MSW incineration [1]	29%	-	-	7.735 t CO2 Eq
RDF co-incineration [2]	64%	36%	-	2.396 t CO2 Eq
Composting [3]	71%	-	29%	-
Anaerobic digestion [4]	71%	-	29%	-
MBT [5]	53%	16%	32%	1.227 t CO2 Eq
Separate collection [6]	77%	-	23%	-
Separate collection + MBT [7]	46%	8%	46%	613 t CO2 Eq

[1] 80 % of metals recycled from slag
[2] 80% of burnable fractions are separated for RDF, 80 % of metals recycled
[3] 60% of organic is separat collected, 55% are recycled
[4] 60% of organic is separat collected, 55% are recycled
[5] 80% of metals and glass are recycled,75% of burnable fractions are recovered
[6] 60% of recyclables are separat collected, 50% are recycled
[7] 60% of recyclables are separat collected, 50% are recycled, 80% of remaining metals and glass are recycled,75% of remaining burnable fractions are recovered
[8] Emission faktor for incineration of MSW: 0,3 t CO2 Eq / Mg waste; substitution effects not considered

2.3.2 Economy

Pre-condition for the implementation of a sustainable waste management system is the financial feasibility. Crucial for the total costs of waste management are the investment of new waste management technology and often underestimated the operational costs in the long run. The attention should be drawn to following points which should be considered in the conception phase.

- Selection of most cost effective technology
- Competition by selection of waste management operators
- Fee system by means of financial incentives

Costs of waste management solutions

In order to get an impression about the cost of the technology proposed in the basic scenarios a rough cost estimation was carried out. Based on the investigated data on waste amounts and composition and the existing waste management infrastructure manufacturers of MBT plants, incineration plants and landfill sites were asked for the investment and operational costs of the respective technology. A preliminary rough cost estimation is given in table 5.

table 5: Preliminary rough cost estimation for MBT, incineration and landfill disposal

	Investment costs		**Operational costs**	**Total investment + operation**	**Reduction of landfill volume**	**Reduced landfill costs**	**Total costs**
	[Million EUR]	[EUR/(Mg*a]	[EUR/(Mg*a]	[EUR/(Mg*a]	[%]	[Million EUR]	[EUR/(Mg*a]
Incineration Plant	10 - 15	41 - 62	35 - 45	76 - 107	71%	13 - 23	63 - 85
MBT Plant	6 - 10	25 - 41	15 - 25	40 - 66	54%	15 - 25	25- 41
Sanitary landfill	8 - 12	10 - 15	10 - 18	20 - 33	0%	20 - 33	20 - 33

Parameter:				
	Inhabitants KM	80.000		
	Quantity of MSW	28.000 Mg/a	1.000.000 Mg	for landfill
	MSW per person	350 kg/p*a		
	repayment period	15a	25a	for landfill
	Interest rate	3,8%	1,0%	for landfill

2.3.3 Social sustainability

The population has to bear the acceptance and the costs of each waste management system. Indicators for the successful introduction and operation of waste management systems are environmental impacts and the cost benefit ratio of the total costs for waste management (invest & operational costs) to net income per household. The World Bank recommends a ratio between 0.6 and 2.5%. Especially the long-term operational costs have to be covered by the lower income households as well. The distribution of the net income and its future development should be properly investigated. Following aspects should be considered:

- Acceptance of waste management system
- Feasibility of cost covering
- Participation of relevant stakeholders (recycling enterprises, waste pickers, …)
- Creation of jobs

3 ASSESSMENT OF SCENARIOS

To find the best fitting waste management concept the basic scenarios has to be assessed. In principle economical, ecological and social criteria can be distinguished. Additionally, local conditions, like the determination of the location or existing framework concepts have to be considered. Costs & financing, legal requirements, the technical feasibility, the search for an appropriate location, accordance to regional concepts or concerns of citizens are strict criteria, which can stop the concept development immediately.

Therefore the costs were calculated by a preliminary rough estimation (refer to chapter 2.3.2). The technical feasibility was verified by interviewing experienced experts and waste treatment manufacturer in countries with similar climate conditions as Khanty-Mansiysk (refer to ***Annex IV*** of the final report).

Environmental criteria derive from the impact of substances with harmful effects on the environmental compartments such as soil, water and air. Moreover noise protection has to be considered. Further environmental criteria are carbon emission and resource efficiency (refer to chapter 2.3.1, environmental indicators).

The social criteria, which includes the acceptance of the citizens, the affordability of the citizens to pay cost-covering fees, the effects on local employment or health risks, should not be underestimated in the concept development process.

Finally the disposal security and the reduction of deposition are crucial criteria.

At this stage of the WMC development the proposed and refined scenarios are assessed according to the defined evaluation and selection criteria. This has to be done with the involvement of the responsible administration in KM municipality. Together with representatives of the administration further need for feasibility studies and pilot projects can be identified. The evaluation and selection criteria have to be discussed and fixed and final questions regarding to the scenarios could be clarified. This process took place from September until November 2011. The following comments and concerns were expressed:

- The concept should describe the implementation of the separate collection including arrangement drawing and time schedule for the recycling container.
- Additional to the bring banks for separate collection of recyclables it has been suggested to implement a recycling centre, where recycling materials (if possible for a fee) could be delivered.
- The German experts were asked for applications of recyclables and innovative ideas for new products from recycling material (e. g. patch pavements made from plastics, flower tubs made from plastics etc.)
- Possibilities of utilization of Refuse Derived Fuels (RDF) are to be found. It was discussed that an incineration plant using RDF for electricity and steam generation could deliver power and heat for the MBT and mechanical sorting plant.
- Further specification of costs and equipment needed for MBT.

In order to select the best fitting waste management system for a given disposal area uniform criteria and objectives has to be developed. The criteria were derived from the strategic objectives, discussed with the representatives of KM administration and finally agreed.

(1) Costs & financing

(2) Environmental impact

(3) Carbon emission reduction

(4) Resource efficiency

(5) Reduction of deposition

(6) Disposal of hazardous residues from waste treatment

(7) Accordance with regional waste management concept

(8) Flexibility

(9) Waste disposal security (includes the risks of a functioning recycling industry)

(10) Social impact (health, public acceptance, Impact on local employment)

The assessment of the proposed scenarios is based on the results of the status quo analysis (refer to ***Annex I***), the description of the waste management technologies, the selection criteria, additional feasibility studies on technical issues under severe climate conditions and an objective evaluation scheme.

In table 6 the core assessment criteria are summarised and rated by a 5 -point scale (++, +, 0 -, - -). The assessment is relative to the baseline scenario (sanitary landfill site, without recycling activities or deposition reducing measures). This means, that (++) is a significant improvement for the respective scenario to the baseline, (0) is no change with respect to the status-quo and (- -) is a distinct disadvantage for the respective scenario.

table 6: Results of scenario evaluation

Criteria	Scenario 0 Baseline	Scenario 1 Recycling	Scenario 2 Biological treatment	Scenario 3 Incineration
Costs & financing	++	0	+	-
Environmental impact	--	+	+	0
Carbon emission reduction	--	++	+	0
Resource efficiency	--	++	0	-
Reduction of deposition	--	+	0	++
Disposal of hazardous residues from waste treatment	0	0	+	-
Accordance with regional waste management concept	0	++	-	-
Flexibility	-	++	0	--
Waste disposal security (includes the risks of a functioning recycling industry)	+	+	+	++
Social impact (health, public acceptance, impact on local employment)	0	+	+	-

In order to come to a final decision, the importance of each criteria has to be weighted. Therefore an opinion poll was carried out by representatives of the responsible administration in Khanty-Mansiysk. The result of the opinion poll was transferred to a weighting-matrix. Independently from this result, a second weighting-matrix was proposed by the German consultants. The weighting matrix is shown in table 7.

table 7: Evaluation matrix

Criteria	Weighting Factor Khanty-Mansiysk administration	Weighting Factor German Consultants
Costs & financing	33%	30,0%
Environmental impact	24%	10,0%
Carbon emission reduction		5,0%
Resource efficiency		2,5%
Reduction of deposition	19%	10,0%
Disposal of hazardous residues from waste treatment		2,5%
Accordance with regional waste management concept	14%	20,0%
Flexibility	5%	5,0%
Waste disposal security (includes the risks of a functioning recycling industry)		5,0%
Social impact (health, public acceptance, Impact on local employment)	5%	10,0%
Total	100%	100%

In the final step of the scenario assessment the individual evaluations for each criteria were summarised by weighting factors to the overall result for each scenario. Because of slightly deviating weighting factors between Russian and German experts the calculation was carried out separately. The results of the scenario assessment are listed in table 8. It can be seen, that both evaluations prefer the scenario 1 (Recycling option).

table 8: Overall result of scenario evaluation

Criteria	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**
	Baseline	**Recycling**	**Biological treatment**	**Incineration**
Result of assessment representatives KM	**½ -**	**+**	**½ -**	**¼ -**
Result of assessment German Consultants	**0**	**+**	**0**	**½ -**