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Waste Management

Implementation Plan for
Residual Municipal Solid Waste
Region of Hradec Králové

Twinningový Projekt

FINANCNÍ NÁSTROJE

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Waste Management
Hospodarení s odpady

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Summary

Waste management planning involves the comparison of options to achieve given objectives within a legal and policy framework. This comparison of options has also been recommended as one of the requirements defined during the development of the Regional Waste Management Plan for the Hradec Králové region. At the same time it also is a basic requirement for any application for co-financing of projects from EU funds.

This Implementation Plan examines a number of options for the management of residual municipal solid waste in the Hradec Králové region, together with the Pardubice region. Residual municipal solid waste is what remains for disposal after the process of waste minimisation, and after separate collection, recycling, composting and other forms of recovery. It is important to emphasise that this Implementation Plan does not address these waste minimisation and source separation activities but rather takes as its starting point a quantity of residual waste for which there is no further use and that must therefore be disposed. These activities are also however a vital part of any overall implementation plan for the integrated management of municipal solid waste (MSW) as a whole.

The objectives to be met in the disposal of residual MSW are given by the policy and legal framework of the European Union and the Czech Republic. In addition to technical requirements and emission controls on landfills and incinerators, there is also an important requirement (from the EC Landfill Directive) to reduce the landfilling of biodegradable MSW. This requirement means that there must be a modest reduction in the amount of biodegradable MSW landfilled by 2010, a more marked reduction by 2013, and a further reduction by 2020 – and this in the face of expected growth in the amount of biodegradable MSW produced. This means that the current system of MSW management is not sustainable.

There are two main technical options for how to stabilise biodegradable MSW prior to final disposal in landfill: thermal stabilisation and biological stabilisation. These two approaches can be applied separately or in combination. Both classical incineration (with no biological treatment) and combinations of mechanical-biological-thermal (MBTh) treatment are in widespread use in neighbouring Austria and Germany and there is no doubt about their technical feasibility.

This document considers five different options for the disposal of residual MSW, involving various combinations of the two main approaches:

- Option 1 – classical incineration with energy recovery and with minimal pre-treatment

- Option 2 – mechanical-biological-thermal treatment, with different preference given to the biological and thermal components (2a – preference to thermal treatment, 2b – preference to biological treatment, 2c – balanced thermal and biological treatment)

- Option 1+2c – a combination of ‘classical’ incineration for the towns of Hradec Králové and Pardubice and other larger population centres in the vicinity (Option 1), and mechanical-biological-thermal treatment (Option 2c) for parts of the two regions further away from the two regional capitals.

All the options are defined so as to deliver the minimum needed to meet the requirements for reducing biodegradable MSW in the three key target years defined by the Landfill Directive, which for the Czech Republic are 2010, 2013 and 2020. Most attention however is given to the

period from 2013-2019, since any system proposed now will not be brought into operation much before the year 2010, and the period 2010-2012 is only three years.

A simple assumption was made concerning the quantity of residual MSW for disposal over the period to 2020: that any growth in total MSW waste arisings will be entirely offset by more intensive source separation activities, so that the quantity of residual MSW for disposal remains constant at its current level. Complete data on the current amount of residual MSW disposed was not available and it was assumed that the average figure for the region corresponds to 282kg per person per year, or 300 000 tonnes per year for the two regions combined.[1]

For each of the options, the waste flows were then determined in line with the definition of the five options, on the basis of which the capacities of the necessary treatment installations were established. A simplified cost-benefit analysis of the options was then undertaken as follows:

- capital and operating costs were estimated, based on the costs of similar installations in neighbouring countries (Germany and Austria)[2] but with some adjustment for Czech conditions;
- the energy recovered in each option was estimated;
- the transport intensity of each option (including only longer-distance transport, i.e. excluding transport by waste collection vehicles) was estimated; and
- based on some technical assumptions, an index of the mass of emissions of pollutants emitted to air was estimated.

The options have been defined so as to be comparable. That is to say, all the options include all of the main elements needed for the option to function. Each option is self-contained concerning the capacities required for the thermal treatment of waste, and does not rely on possibly existing capacities for the co-incineration of refuse-derived fuel. The study only assumes the availability of sufficient landfill capacity at a given landfill price. It should also be stressed that the only material for recycling arising from the disposal options are ferrous and non-ferrous metals separated from the waste stream. All the biologically-treated waste is landfilled (there is no intention to produce or market compost or similar such product).

The cost comparison of the options was also strengthened by an analysis of the sensitivity of the results to changes in a number of input variables, as follows:

- lower or higher energy prices;
- higher transport costs;
- a higher calorific value for the so-called ‘light fraction’ of waste separately mechanically for subsequent incineration;
- a higher interest rate;
- longer depreciation periods for writing off the investments;
- lower costs for a simpler biological treatment process;
- no costs for disposal of the slag from incineration;
- utilisation of heat only for the production of electricity, not for distribution of heat; and
- inclusion in the calculations of the CZK 500 landfilling charge.[3]

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[1] Later comparison with the latest available data indicates that current production of residual MSW is probably about 10% lower. Figures provided by ISES, s.r.o. for the Pardubice region show that recorded waste arisings in 2002 were 199 kg/person of domestic waste and 12kg/person of bulky waste. Adding an estimated 20% for trade waste, this brings the estimated total residual MSW to 253kg/person, which is 10.5% less than the figure of 282 kg/person used in the study. It is not however considered likely that this difference will have a significant impact on the study’s conclusions.

[2] The technical requirements for such installations are higher in Austria and Germany than the requirements currently proposed by the European Commission.

The effects of grant support (of 50% and 70%) on the costs per tonne of waste processed were also calculated.

The findings show that the lowest cost solution is Option 2b, which (in the period to 2019) involves no incineration but only biological treatment and landfilling. This option is rejected because it is inconsistent with Czech and EU policy to recover energy from waste before final disposal. The basic cost of the other options ranges from CZK 2100 per tonne (Option 1+2c) to CZK 2300 per tonne (Option 2a), a difference of less than 10%. There is however a larger difference in the capital investment needed for the different options – least capital intensive is Option 2c, with costs of CZK 2480 million; most capital intensive is Option 2a, with costs of CZK 4620 million (almost twice as much as Option 2c).

The study also briefly assesses the risks associated with each of the options. There is no option that has significantly lower overall risks than the others, but the risks are different. The classical incineration option (Option 1) has lower risks in terms of the cooperation needed with other parties (because there is only one major new investment), but greater risks in the event that the incinerator is unavailable for technical reasons. The other options are less reliant on the incinerator in the event of its non-availability, but are more demanding in terms of the cooperation needed with other parties.

The table below presents the overall results of the comparison.

Table 1 Overall ranking of the options

	Option				
	1	**2a**	**2b**	**2c**	**1+2c**
Legal assessment	1	1	Not compliant	1	1
Economic assessment	4	5	1	3	2
Environmental assessment	3	3	1	3	2
Utilisable energy	*2*	*1*	*5*	*4*	*3*
Emissions to air	*5*	*4*	*1*	*2*	*3*
Transport	*3*	*5*	*1*	*4*	*2*
Risk assessment	No clear difference				
Total	**3**	**4**	**Not compliant**	**2**	**1**

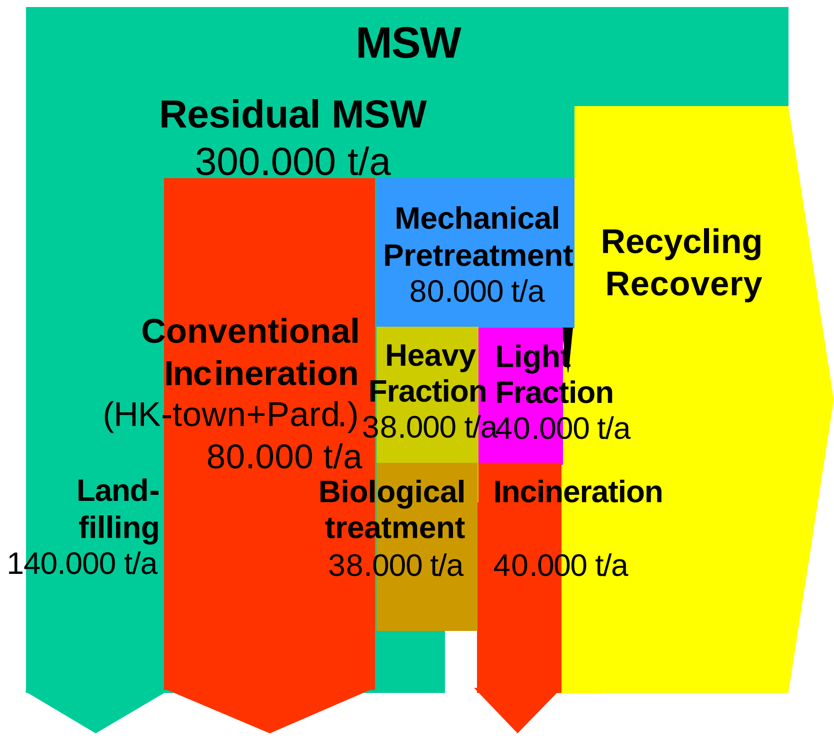
Note: the numbers presented here are the ranking of the options based on the quantitative findings of the study. The overall ranking of the environmental issues gives equal weight to each of the three criteria utilisable energy, emissions to air and transport intensity.

The overall comparison suggests that the best option – as well as the cheapest option that complies with Czech legislation and EU requirements – is the combined Option 1+2c. The waste flows associated with this option are presented graphically below, for the period from 2013 to 2019. Even this option is however considerably more expensive than landfilling, which in 2010 is assumed to cost CZK 800 plus the CZK 500 charge, making a total of CZK 1300 per tonne. Grant support of over 50% of investment costs would however be sufficient to make this option cost-competitive with landfill. This level of grant support, and the total amount of grant needed (at least CZK 1450 million, or €45 million) could be available from the Cohesion Fund.

[3] This was not included in the basic calculation because it represents a transfer of resources to the beneficiaries of the tax, not a genuine cost to the economy.

Further work is needed to confirm the cost estimates made in this study and to develop in more detail the chosen option. The practical implementation of Option 1+2c offers an additional advantage in that it could be done in two stages, starting with the classical incinerator for the central, most heavily populated part of the two regions (to be implemented by 2010). The system could later be extended to include the rest of the two regions, with the construction of the necessary mechanical-biological treatment plants (by 2013). It is also possible to begin with the construction of installations for the mechanical-biological treatment of MSW (by 2010) and then to construct an incinerator. Incineration of sewage sludge that is too polluted to be used in agriculture should also be considered in developing the preferred option.

Figure 1 Flow chart for MSW according combined Option (1+2c) for both regions Hradec Králové and Pardubice



Content

page

1. Introduction 1

2. Planning Process 1

2.1. Description of the Planning Process 1

2.2. Regional and Legal Frame 2
2.2.1. Values 2
2.2.2. Legislative Basis 3
2.2.3. National Waste Management Plan 3
2.2.4. Infrastructural Basis 3
2.2.4.1 Landfills 3
2.2.4.2 Incineration Plants 4
2.2.5. Current Waste Management Figures 4

3. Future development of Waste Quantities 5

4. Basic Technical Alternatives 7

4.1. Thermal Treatment 7

4.2. Mechanical / Biological / Thermal treatment 8

5. Options 11

5.1. Capacities of disposal facilities needed 11

5.2. Description of the Options 12
5.2.1. Description of Option 1 13
5.2.2. Description of Option 2 13

5.3. Capacities of Treatment Plants needed 16
5.3.1. Capacities of Treatment Plants needed according Option 1 16
5.3.2. Capacities of Treatment Plants needed according Option 2a 18
5.3.3. Capacities of Treatment Plants needed according Option 2b 20
5.3.4. Capacities of Treatment Plants needed according Option 2c 22

6. Feasibility check of a Co-operation with the Region of Pardubice 25

6.1. Option 1 - Conventional Incineration plant for residual MSW 25

6.2. Option 2c - Mechanical treatment as few as needed, incineration of the light fraction and biologic treatment of the heavy fraction 26

6.3. Combination of options 1 and 2c 27

7. Assessment of Options 29

7.1. Legal assessment 29

7.2. Economic assessment 30
7.2.1. Basic Figures of the compared options 30
7.2.2. Results of Cost Accounting 32
7.2.3. Sensitivity Analyses of Cost Accounting 33

7.3. Ecological assessment 38
7.3.1. Energy balance 38
7.3.2. Emissions to the air and to ground water 39
7.3.3. Transport 40

7.4. Risk assessment 41
7.4.1. Changing Quantities of MSW 41
7.4.2. Changing Composition of MSW 42
7.4.3. Unexpected development of separate collection 42
7.4.4. Planned and unplanned unavailability of single facilities of the disposal system 42
7.4.5. Unexpected change of national legislation 42
7.4.5.1 Landfill taxes 42
7.4.5.2 Calculation method of biodegradable content of MSW (BRKO) 42
7.4.6. No/little agreement/cooperation between different investors/operators of facilities within one option 43

7.5. Overall Ranking 43

Literature 44

List of Abbreviations

BRKO	**B**iologicky **R**ozložitelných **K**omunálních **O**dpadu (biodegradable municipal solid waste)
CR	Czech Republic
HK	Hradec Králové
MBTh	**M**echanical / **B**iological / **Th**ermal Treatment of waste
MBT	**M**echanical / **B**iological **T**reatment of waste
MoE	Ministry of the Environment
MSW	Municipal Solid Waste
NWMP	National Waste Management Plan
WMP	Waste Management Plan(s)
RWMP	Regional Waste Management Plan
RWMS	Regional Waste Management Strategy (Koncepce)
RA	Regional Authority

1. Introduction

Waste management planning involves the comparison of options to achieve given objectives within a legal and policy framework. This comparison of options has also been recommended as one of the requirements defined during the development of the Regional Waste Management Plan for the Hradec Králové region. At the same time it also is a basic requirement for any application for co-financing of projects from EU funds.

This Implementation Plan examines a number of options for the management of residual municipal solid waste in the Hradec Králové region, together with the Pardubice region. Residual municipal solid waste is what remains for disposal after efforts have been made to minimise the quantity of waste arising in the first place, and after separate collection activities have diverted appropriate parts of the waste stream to re-use, recycling, composting and other forms of recovery. It is important to emphasise that this Implementation Plan does not address these waste minimisation and source separation activities but rather takes as its starting point a quantity of residual waste that must be disposed. These activities are also however a vital part of any overall implementation plan for the integrated management of municipal solid waste (MSW) as a whole.

2. Planning Process

2.1. DESCRIPTION OF THE PLANNING PROCESS

Every planning process needs a basis. The basis is given by values, by the legislation, by the relevant infrastructural basis and last but not least by waste management figures.

From this basis it is needed and possible to define a vision and operational targets.

How to reach the targets and to move towards the direction of the vision is to be drawn up in an operational plan. In our case the Regional Waste Management Plan.

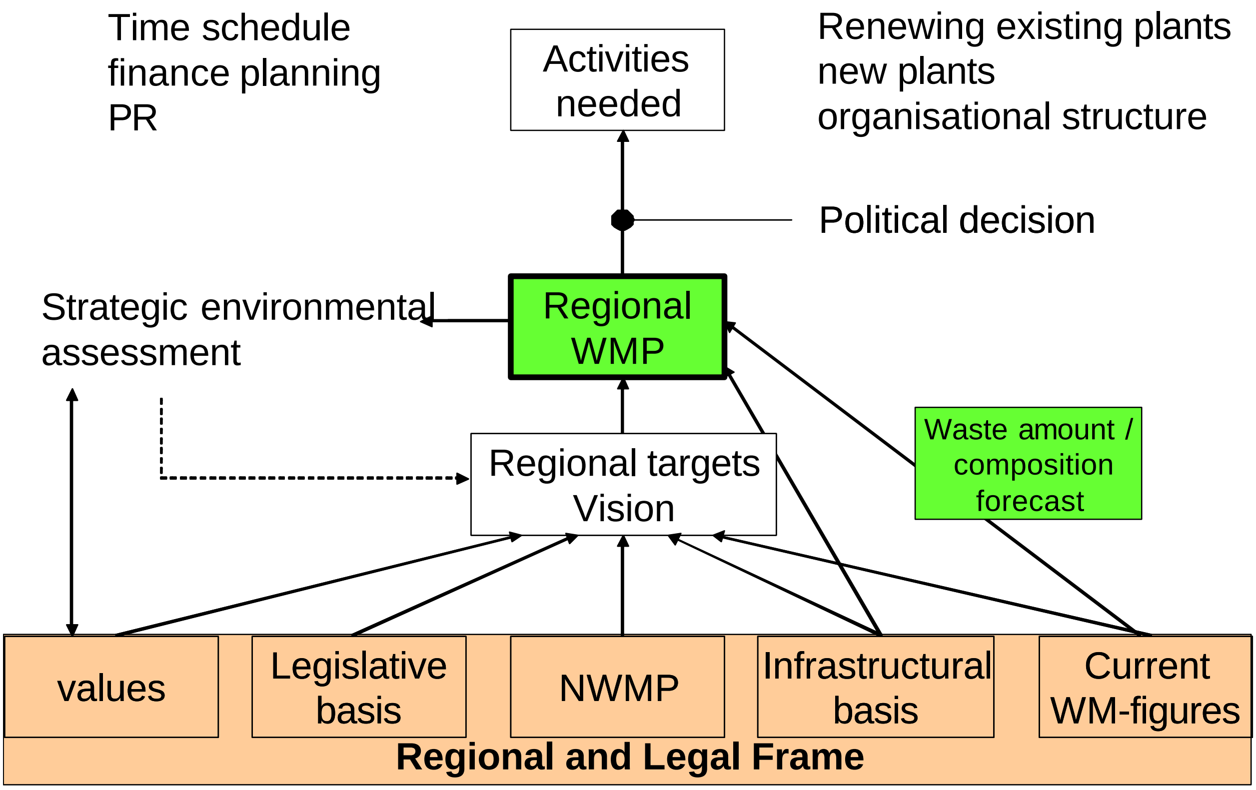
This plan has to be accompanied by a strategic environmental assessment. In that assessment the public has to be involved and the environmental impacts of different scenarios or options have to be approved. May be that some changes in the vision have to be done after that assessment. The assessment has to include a check if the plan paid attention to the values given.

The plan has of course to be decided by the elected bodies of the region, the regional council.

After all that have been done the way is free for designing detailed projects which fit to the plan. Project management has additionally to the technical planning to involve finance planning and time planning as well as public relations and development of organizational structures.

The planning process described above is shown in the following picture.

Figure 2 Planning Process



The implementation plan is to be seen as the result of work done in the green coloured boxes "Regional WMP". The inputs shown in the boxes at the base of the figure and coloured red give the frame for the planning process and are the input data for the calculation that has to be done.

2.2. REGIONAL AND LEGAL FRAME

2.2.1. Values

The values to be considered in a Regional Waste Management Plan for Hradec Králové can be listed as follows (does not claim completeness):

- Regional infrastructure should be used as much as possible
- Cooperation between neighbour regions should be promoted
- The assessment of options should include at least
  - Economic assessment
  - Ecologic assessment
    - Air quality
    - Ground water protection
    - Pollutants of waste transport
    - Energy usage
  - Sustainability for a period of at least until the year 2020
  - Possible combinations for the treatment of high polluted sewage
- The decision between options has to consider a high ecological standard combined with justifiable costs

2.2.2. Legislative Basis

The main legislative basis to be considered is:

- EC Landfilling Directive
- Act on Waste
- National Waste Management Plan (see below)

2.2.3. National Waste Management Plan

The National Waste Management Plan (NWMP) gives the following main targets which are considered in the implementation plan:

- The share of recycled MSW has to be increased up to at least 50 % by the year 2010
- The quantity of landfilled biodegradable MSW has to be reduced to at most
    - 75 % by the year 2010
    - 50 % by the year 2013
    - 35 % by the year 2020
- Following the "*Methodology of calculation for gradual reduction of landfilled quantity of biodegradable municipal waste" (Metodika BRKO)* the share of biodegradable parts in residual MSW has to be calculated with
    - 45 % until the year 2012
    - 55 % until the year 2019
    - 60 % from the year 2020

2.2.4. Infrastructural Basis

The infrastructural basis for the disposal of residual MSW for the region of Hradec Králové are basically landfills. Incineration plants are located in neighbour regions.

2.2.4.1 Landfills

Within the region of Hradec Králové there are five landfills in operation with a taken quantity of residual MSW in 2002 of about 77.000 tons

Landfill	Operator	Capacity	Planned closure	Landfilled MSW 2002
Kryblice	Marius Pederson	?	?	29.500 t
Rtyne v Podkrkonoší	Association of municipalities	?	?	18.200 t
Krovice	Marius Pederson	?	?	22.400 t
Dolní Branná		36.000 m³	2010	7.100 t
Albrechtice, Nová Ves	ODEKO s.r.o.	80.000 m³	2010	100 t
Total				77.000 t

Some of these landfills are facilities basically suitable for possible future mechanical-biological preteatment plants, which are:

- Krovice, operated by Marius Pedersen
- Kryblice, operated by Marius Pedersen
- eventually landfill Rtyne v Podkrkonoší, operated by Marius Pedersen
- Nová Ves, operated by Odeko

Currently an important share of residual MSW is disposed at landfills which are located in the region of Pardubice.

2.2.4.2 Incineration Plants

Two facilities which are located in neighbour regions take waste for incineration, which are:
- Incineration plant at Liberec for MSW
- Cement kiln at Prachovice where different types of waste are incinerated

In Opatovice a power station is under operation. The plant is fired with brown coal. For the future an incineration plant for MSW or parts of it is planned to be built at that facility.

2.2.5. Current Waste Management Figures

Complete data on the current amount of residual MSW disposed were not available and it was assumed that the average figure for the region corresponds to 280kg per person per year, or 300 000 tonnes per year for the two regions combined. This figure was agreed with the Hradec Králové regional authority as the basis for the work on the Implementation Plan.

Later comparison with the latest available data (April 2004) indicates that current production of residual MSW is probably about 10% lower. Figures provided by ISES, s.r.o. for the Pardubice region show that recorded waste arisings in 2002 were 199 kg/person of domestic waste and 12kg/person of bulky waste. Adding an estimated 20% for trade waste, this brings the estimated total residual MSW to 253kg/person, which is 10.5% less than the figure of 282 kg/person used in the study. It is not however considered likely that this difference will have a significant impact on the study's conclusions.

The following table shows the figures for the year 2001 which is the basis for all later calculations and forecasts.

Table 2 Waste quantities of the year 2001 used as basis for all calculations and forecasts

	Unity	Quantity	kg/inh.a
Disposed MSW	Tons/year	156.000	282
Total amount of MSW	Tons/year	190.850	345
Separate Collected	Tons/year	34.850	63
share collected separately (by mass)		18%	
of which			
Biowaste	Tons/year	3.000	5
Paper	Tons/year	7.500	14
Glass	Tons/year	7.400	13
Plastics	Tons/year	5.200	9
Metals	Tons/year	10.750	19
Textiles	Tons/year		
Wood	Tons/year		
hazardous components	Tons/year	1.000	2
Biodegradable			
Disposed BRKO	Share of disposed MSW	45%	
Disposed BRKO	Tons/year	70.200	127

Waste composition is not known in detail. Under consideration of the "*Metodika BRKO*"[4] the share has to be calculated with 45 %.

Additionally to MSW in the region of HK sewage sludge is produced which is not able to be utilized because of high content of heavy metals. The future MSW disposal method should take into consideration the need for the disposal of highly polluted sewage sludge too.

3. Future development of Waste Quantities

It is assumed that the quantity of residual MSW will be stable for the calculating period. Increasing waste quantities will be compensated by increasing quanities of waste collected separately for recycling purposes.

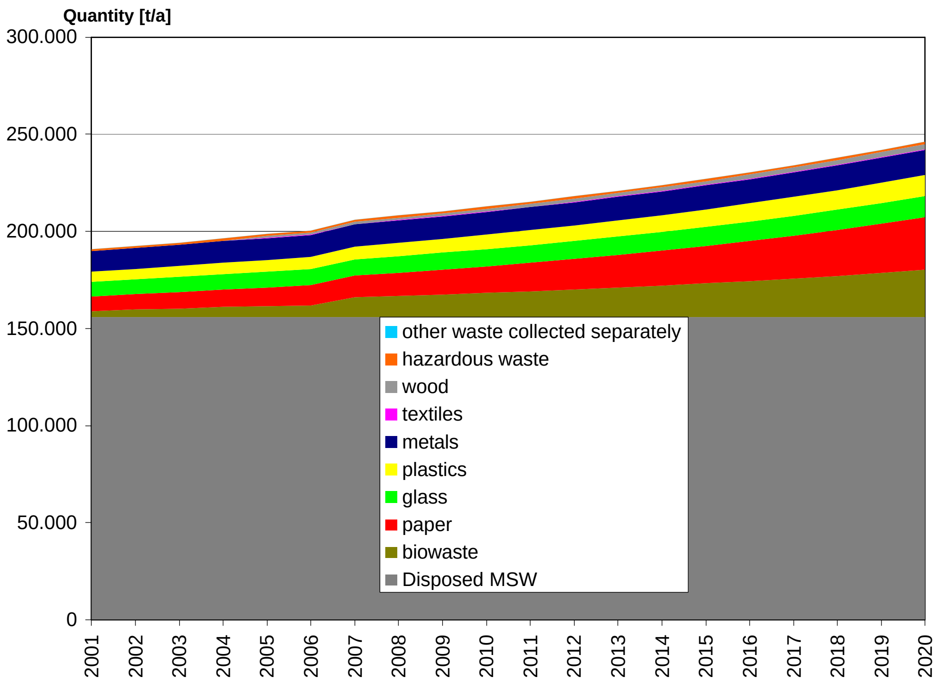
The following table shows the waste quantities which are expected in the planning period until the year 2020. The annual growth of the quantitiy of total MSW is expected with about 1,5% per year. The figures are agreed as a basis for an assessment of different options of the disposal of residual MSW. Concerning the targets of the NWMP of at least 50 % recycled MSW the plannings in future separate collection would have to be more ambitious. Such higher rates of separate collected MSW would either reduce the quantity of residual MSW or compensate higher growing rates than calculated currently.

4 Ministry of the Environment: *Methodology of calculation for gradual reduction of landfilled quantity of biodegradable municipal waste*

Table 3 Development of quantities of MSW, expected

	Unity	2001 (basis)	2006	2010	2013	2020
Disposed MSW	Tons/year	156.000	156.000	156.000	156.000	156.000
Total amount of MSW	Tons/year	191.000	200.000	213.000	221.000	246.000
Separate Collected	Tons/year	34.850	40.200	56.800	64.800	90.000
share collected separately (by mass)		18%	23%	29%	29%	37%
of which						
Biowaste	Tons/year	3.000	5.700	12.300	15.000	24.000
Paper	Tons/year	7.500	10.500	14.000	17.000	27.000
Glass	Tons/year	7.400	8.200	8.800	9.400	10.800
Plastics	Tons/year	5.200	6.300	7.400	8.300	11.000
Metals	Tons/year	10.750	11.300	11.800	12.100	13.000
Textiles	Tons/year		200	220	240	270
Wood	Tons/year		1.100	1.400	1.700	2.800
hazardous components	Tons/year	1.000	1.050	1.100	1.130	1.200
Biodegradable parts of MSW disposed						
Disposed BRKO		45%	45%	45%	55%	60%
Disposed BRKO	Tons/year	70.200	70.200	70.200	85.800	93.600

Figure 3 Development of quantities of MSW, expected



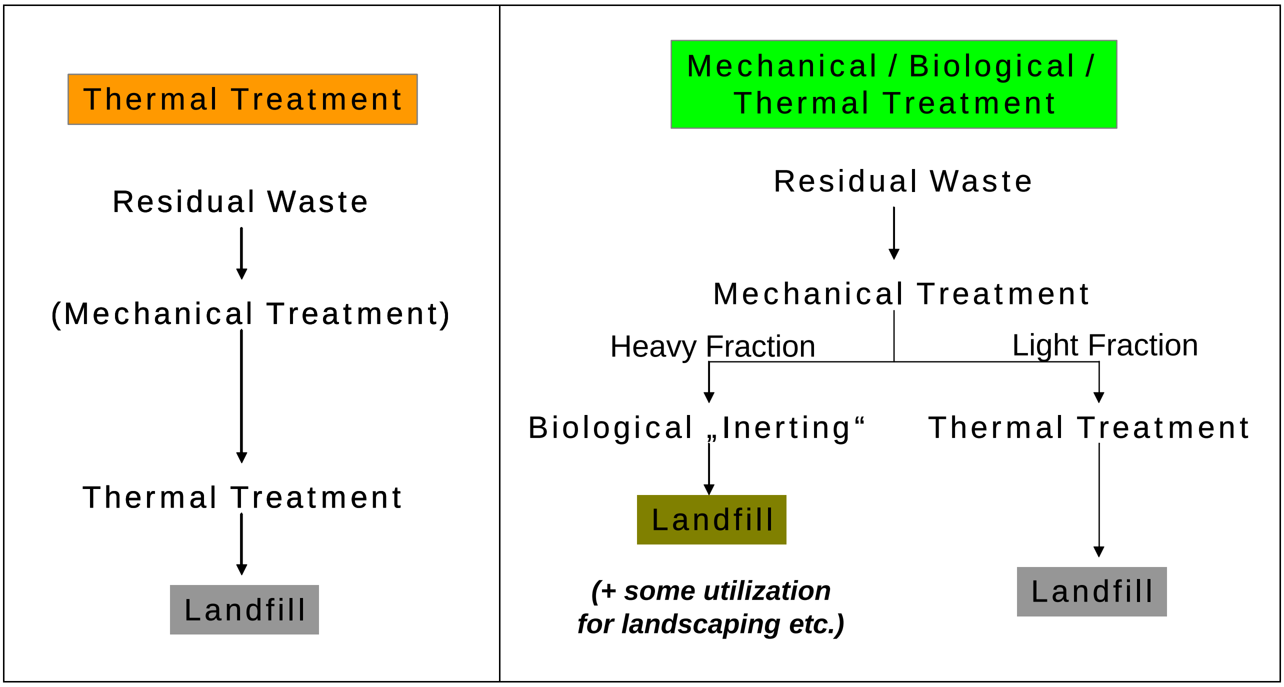
The quantities of sewage sludge to be disposed are not available currently.

4. Basic Technical Alternatives

For the treatment of residual MSW with the aim to reduce the landfilling of biodegradable wastes are two basic technical alternatives available. The two alternatives can be combined in different ways. The basic alternatives are:

- Thermal treatment
- Mechanical / Biological / Thermal treatment

Figure 4 ***Basic technical alternatives*** **for residual waste treatment prior to landfill**



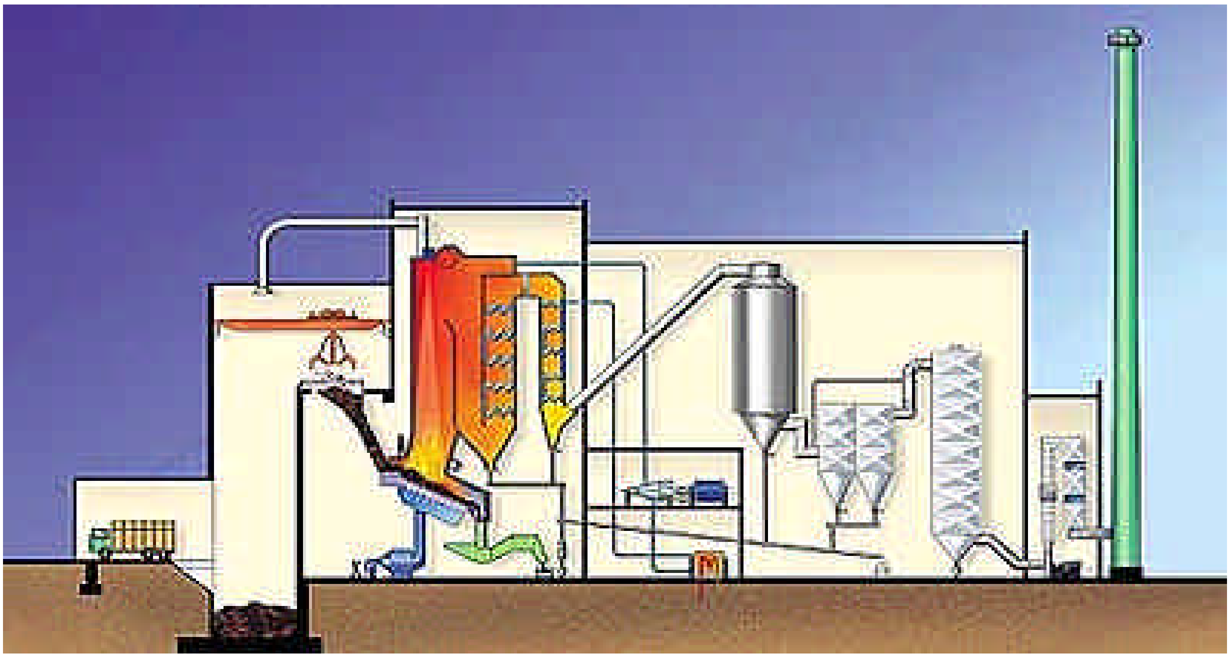
4.1. THERMAL TREATMENT

The thermal treatment will be done normally in so called mass burn incinerators. In such facilities the MSW is incinerated as delivered from the collection. The waste is incinerated on a grid. The not burnable parts are taken off as slag from the bottom. The heat generated will utilized in the vessel. After cooling the flue gas and utilizing the energy the flue gas will be cleaned in different parts of a flue gas cleaning system. After passing that cleaning unit the flue gas leaves the chimney to the environment.

Solid residues are slag and ash. Slag is a material which can be landfilled usually at landfills suitable for MSW. Ashes are residues from the flue gas cleaning unit. These wastes are highly contaminated with heavy metals and have to be handled as hazardous waste.

The following picture shows a typical construction of a mass burn incineration plant for MSW.

Figure 5 Typical construction of a mass burn incineration plant



Delivery Grid Energy recovery
Bunker Vessel Flue Gas Cleaning Unit

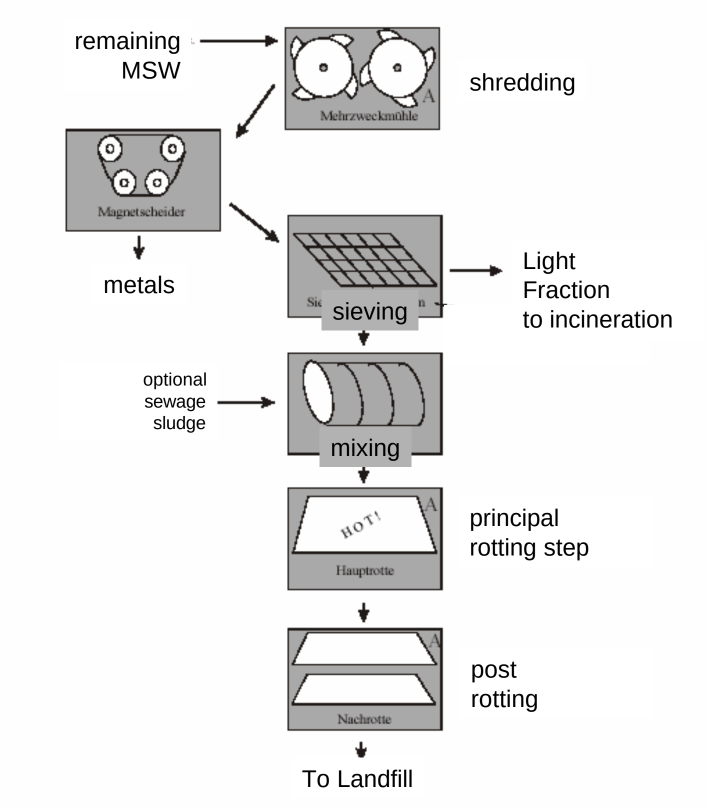
4.2. MECHANICAL / BIOLOGICAL / THERMAL TREATMENT

A combination of treatment methods is the so called MBT Mechanical-Biological-Thermal treatment. The idea of the combination of treatment methods is to combine the advantages of waste incineration - which is the feasibility of energy recovery - with a biological degradation of that parts of the waste which have a low calorific value, a high water content or which are inert.

In such a combination of methods the three different treatment steps can be done at different locations. So it is possible to situate the mechanical treatment very close to a town where the waste comes from. The biologic treatment can take place at a landfill - where the waste will be landfilled after the treatment. The incineration of the parts of the waste with a high calorific value can take place at another location where a suitable incineration plant is situated.

The three different treatment plants can be combined relatively independent to a whole waste management system like bricks. This possible combination of different parts and locations makes the system flexible to changing waste quantities and waste composition.

Figure 6 Typical process of a mechanical-biological treatment of MSW



The picture below shows an example of a rotting box where the principal rotting step takes place.

Figure 7 Example of a rotting box for the principal rotting of heavy fraction from MSW

The incineration of the light fraction can take place in different ways.

- One possibility is to incinerate the light fraction in a mass burn incineration facility. This is a common way for disposal of such wastes. It is done for instance in Austria where the light fraction as output of a mechanical treatment of remaining MSW (Wiener Neustadt, Salzburg) is incinerated in a mass burn incinerator located in Dürnrohr, Lower Austria.

- A second possibility is the incineration of light fraction in a fluidised bed incineration unit. Such facilities need a well defined size of the waste particles. Even this size can be guaranteed after mechanical treatment. The advantage of fluidised be incineration units is the lower need of excess air. This reduces the flue gas quantity and reduces the transport of emissions to the air. Such facilities which are operated with light fraction from MSW are under operation for instance in Vienna, Lenzing (Upper Austria), Niklasdorf (Styria).

- A third possibility is the further treatment of the light fraction to produce secondary fuel or so named RDF (refuse derived fuel). Such secondary fuel is normally produced to be utilized in existing combustion plants as fuel partly replacing primary fuel. This process is named co-incineration. For such a use the secondary fuel needs well specified characteristics (like size, calorific value, ignition characteristic, …). The production of such RDF has to be done in strong cooperation with the facility which uses this secondary fuel. An example for such a facility is located in Retznei (Styria) where secondary fuel is produced which is utilized in cement kilns.

In the further examinations only the incineration in a mass burn incinerator or in a fluidised bed incinerator like described above are considered. Co-incineration is not being assessed.

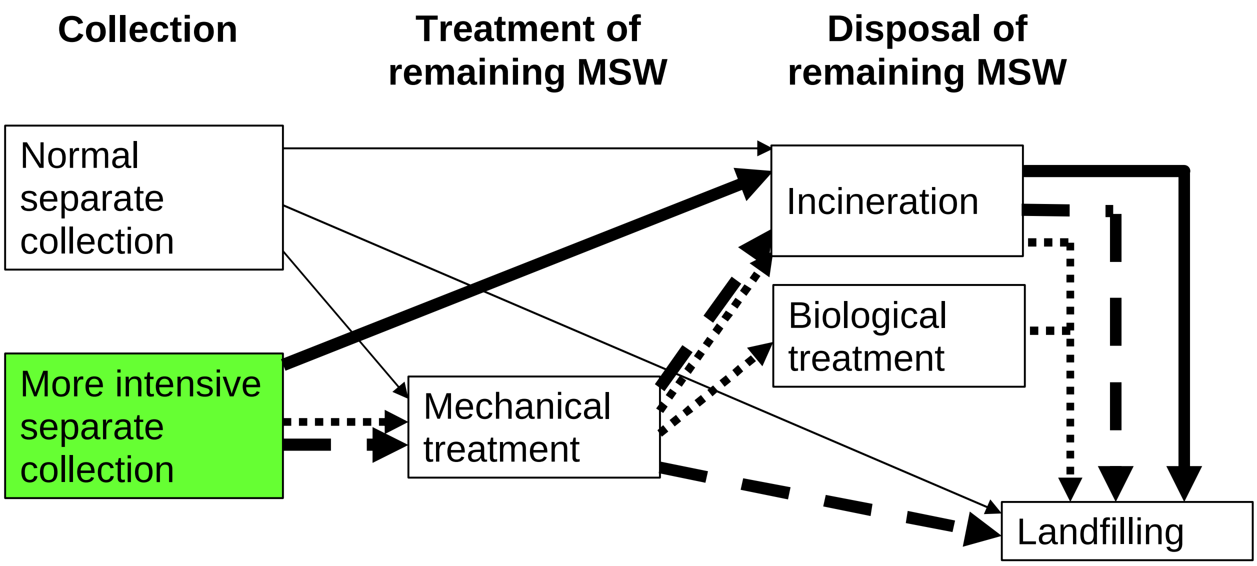
5. Options

From the different thinkable possibilities the Twinning team filtered the two main options which are mass burn incineration and mechanical-biological-thermal treatment (MBT). All of them start with a intensified separate collection of recyclable products (in line with the waste hierarchy and EU and Czech waste management policy).

The MBT-Options are divided in three sub-options. Further a combined option of MBT and mass burn incineration has been assessed. The options are described in more detail in chapter 5.2.

The basic options chosen are to be seen in the following picture. They are marked with bold lines.

Figure 8 Selection of basic options



Note: Not all wastes have to be treated to meet the requirements of the EC Landfilling Directive. The quantities that must be treated are explained in the following chapter

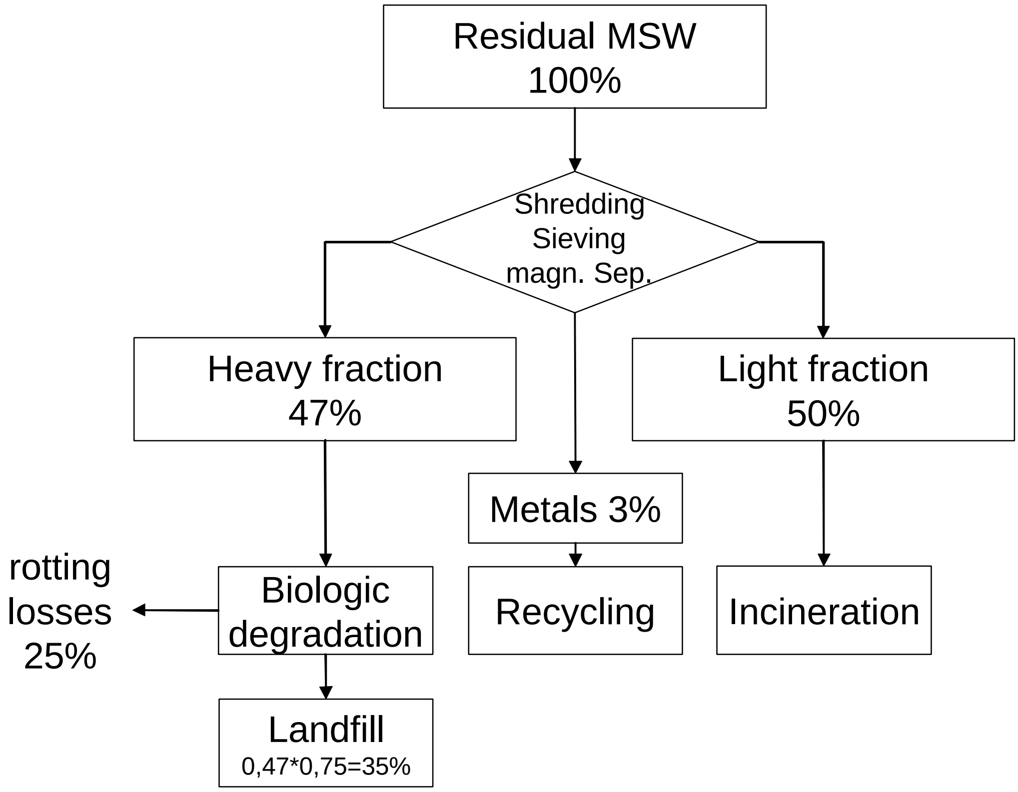
5.1. CAPACITIES OF DISPOSAL FACILITIES NEEDED

For different options the capacities have been calculated. Basis for the calculation are the needs for meeting the requirements of the Landfill Directive which defines reduction rates in the landfilled biodegradable parts of MSW. The calculations are done under consideration of the calculation method given by the MoE (*Metodika BRKO*)[5].

The premise for the calculation was to find the minimum capacities of advanced treatment methods for residual MSW needed to meet the targets for landfilling biodegradable parts of MSW (BRKO).

For the mechanical treatment of MSW in the calculation it is assumed that heavy fraction will have a share of 47 % by mass, light fraction 50 % and metals 3 %. A simple flow chart for that mechanical pre-treatment is shown in the following picture:

Figure 9 Flow chart of mechanical pre-treatment of MSW used in the calculations, by mass



5.2. DESCRIPTION OF THE OPTIONS

In the assessment done two basic options are taken into consideration of which one option is divided into two sub-options. The options are:

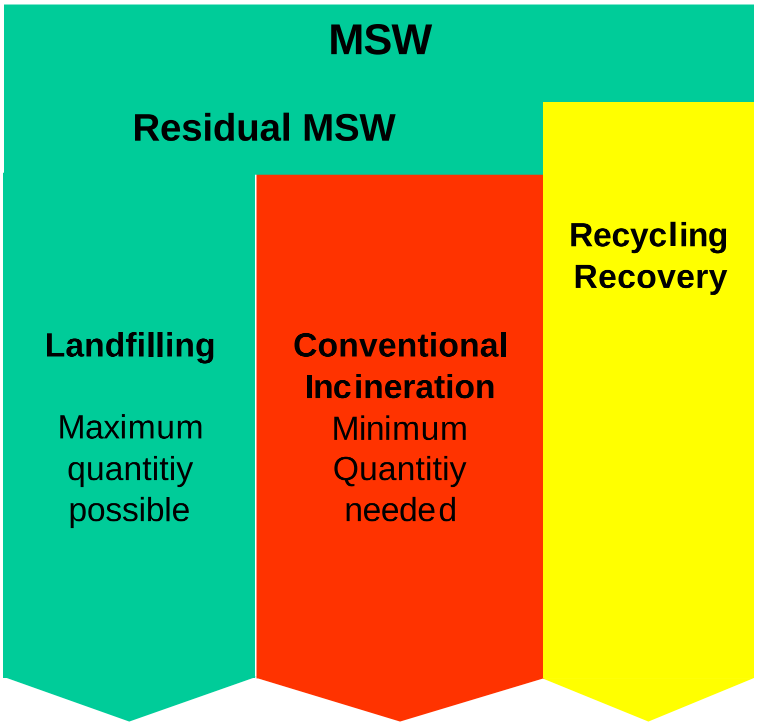
Option 1: Conventional Incineration of residual MSW
Option 2: Mechanical treatment followed by a combination of landfilling, incineration and biological treatment

5 Ministry of the Environment: *Methodology of calculation for gradual reduction of landfilled quantity of biodegradable municipal waste*

5.2.1. Description of Option 1

In Option 1 it is calculated which quantities of residual MSW have to be incinerated at least to fulfil the requirements of EC Landfill Directive concerning the reduction of landfilled biodegradable parts of MSW. The parts of residual MSW which are not needed to be incinerated would be landfilled.

Figure 10 Visualization of Option 1



5.2.2. Description of Option 2

Option 2 describes the quantities of residual MSW which have to be treated by mechanical, biological and thermal methods to fulfil the requirements of EC Landfill Directive concerning the reduction of landfilled biodegradable parts of MSW.

Option 2 has been divided into three suboptions in which

- Option 2a has the priority in the incineration of the light fraction after mechanical splitting. Only if all light fraction is incinerated additional BRKO-reduction needs are achieved by biological degradation;
- Option 2b has the priority in the biological degradation of biodegradable parts of the heavy fraction. This heavy fraction is one of the main two outputs of mechanical pre-treatment. The other main output is the light fraction. Only if all heavy fraction is treated by biological methods additional BRKO-reduction needs are achieved by incineration of light fraction.
- Option 2c is a combination of of biological and thermal treatment of MSW after mechanical splitting. It is taken as a basis that all outputs of a mechanical treatment would be treated further, the heavy fraction by biological methods, the light fraction by incinerating. No outputs of the mechanical treatment would be landfilled directly.

Both options a) and b) show the effects possible to be reached by such a combination of treatment facilities. In reality a large number of options are possible in between the two extreme ones. A sensible option in between is option 2c. The realised combination is a question of later optimisation if one of these options seem to be advantageous in comparison to option 1 as a result of the first assessment.

Figure 11 Visualization of Option 2a

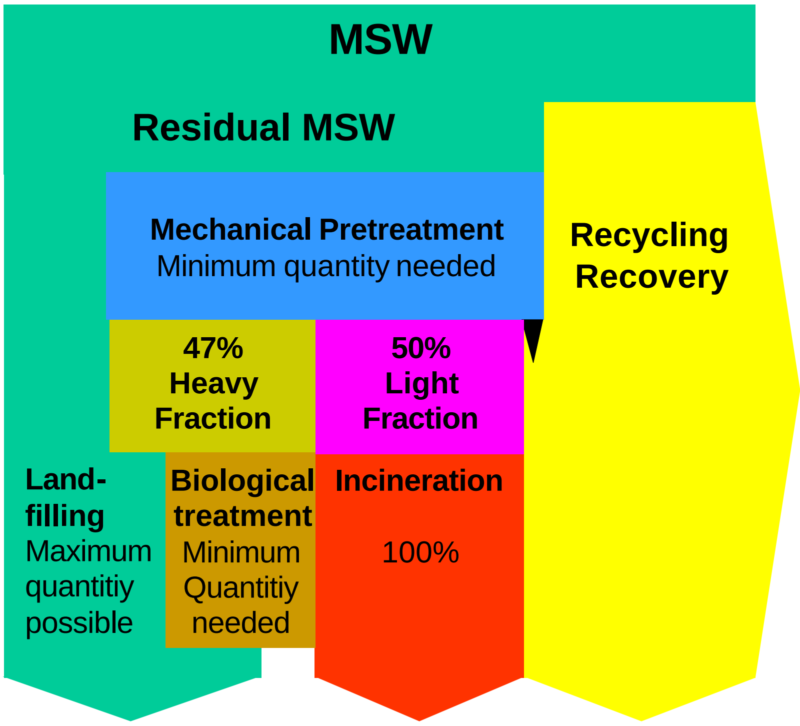


Figure 12 Visualization of Option 2b

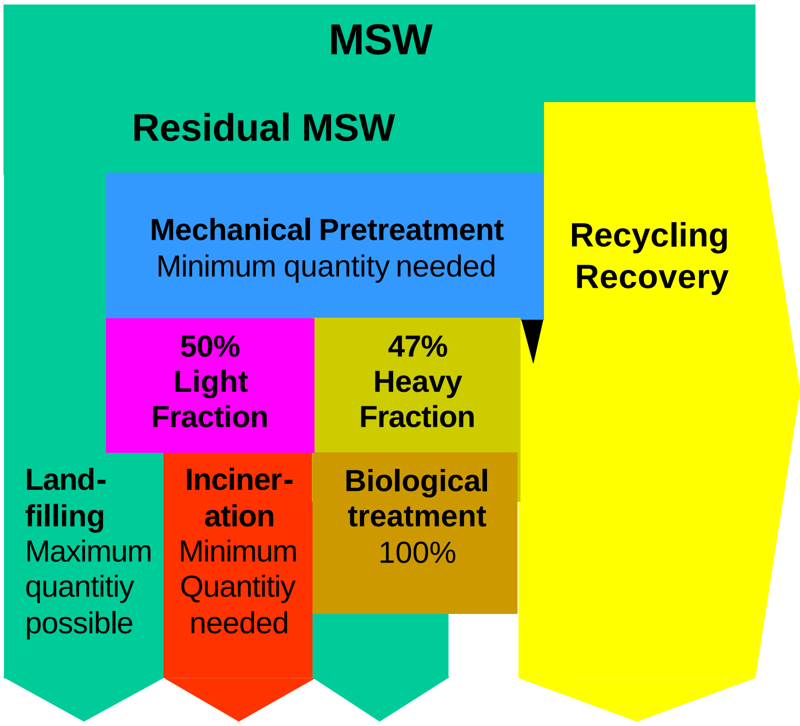
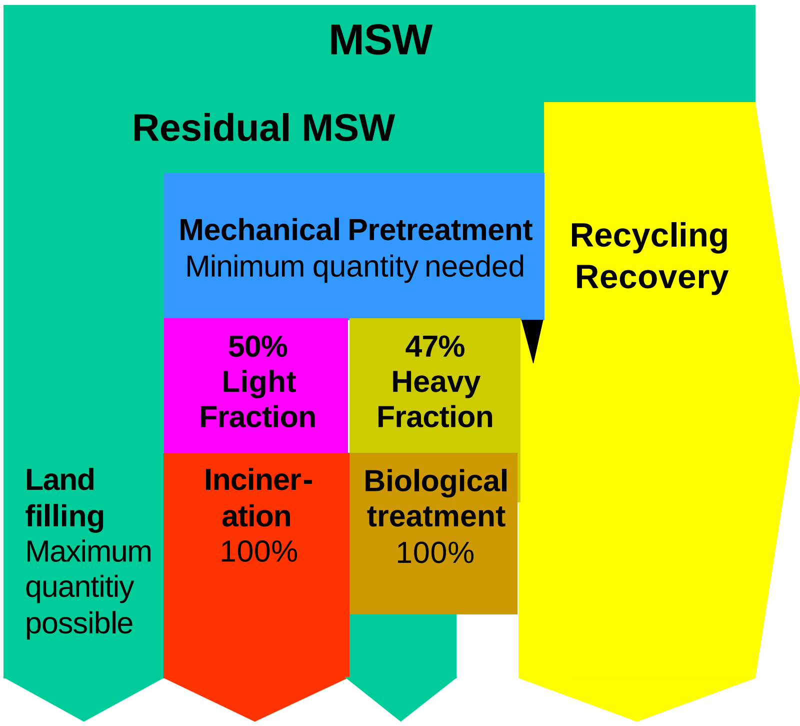


Figure 13 Visualization of Option 2c



5.3. CAPACITIES OF TREATMENT PLANTS NEEDED

Under consideration of the frame described earlier the needed treatment capacities are calculated for each option.

5.3.1. Capacities of Treatment Plants needed according Option 1

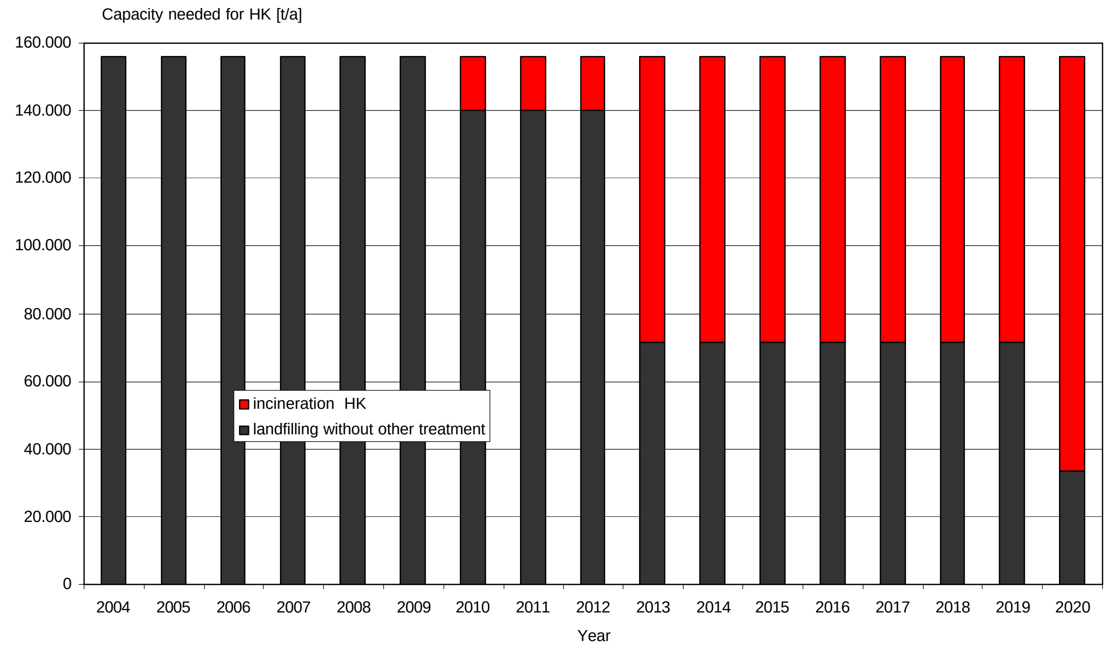
According to option 1 a capacity of 16.000 t/a of a conventional incineration plant is needed. From the year 2013 on a capacity of 85.000 t/a is needed and from the year 2020 on there is a need for a capacity of 123.000 t/a.

Table 4 Capacities of Treatment Plants needed according Option 1

Type of Treatment Plant	Capacity needed for the region of HK [t/a]			
	2004	2010	2013	2020
Conventional Incineration plant	--	16.000	85.000	123.000
Landfill for untreated MSW	156.000	140.000	71.000	33.000
Mechanical Pre-treatment	--	--	--	--
Heavy fraction				
Biological degradation	--	--	--	--
Landfilling	--	--	--	--
Light fraction				
Incineration	--	--	--	--
Landfilling	--	--	--	--
Recycling (metals)	--	--	--	--
Total	156.000	156.000	156.000	156.000

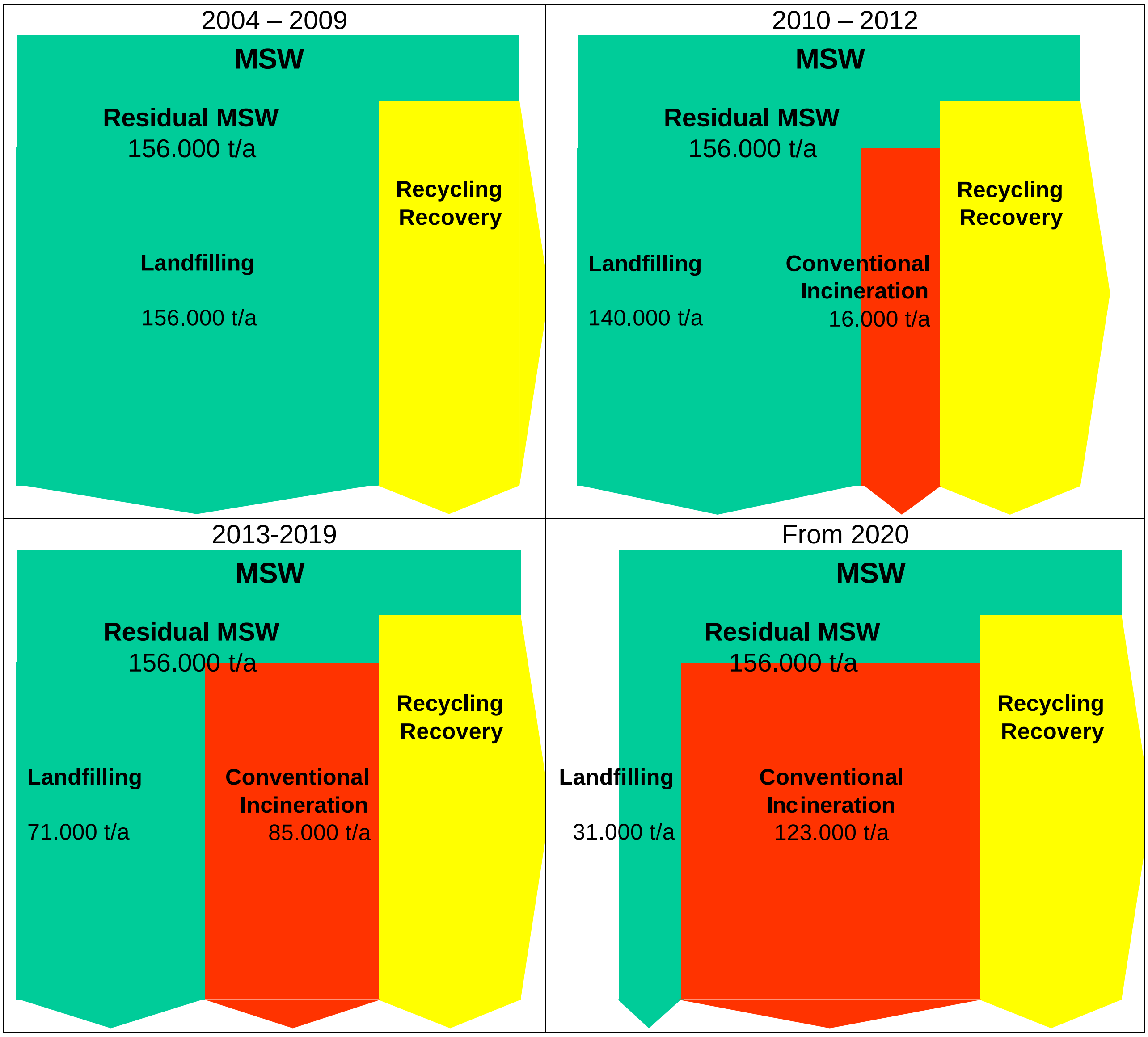
The development of the needed capacity of the incineration plant and the development of landfilled untreated MSW is shown in the figure below. The needed landfill of outputs of an incineration plant like slag and ash are not calculated.

Figure 14 Capacities of Treatment Plants needed according Option 1



Following the results of the calculations the following waste streams can be drawn.

Figure 15 Flow chart for MSW according Option 1



5.3.2. Capacities of Treatment Plants needed according Option 2a

According option 2a a capacity of 48.000 t/a of mechanical pre-treatment plants is needed. From the year 2013 on a capacity of 156.000 t/a is needed. From then all residual MSW would have to be splitted in light and heavy fraction. With such splitting facilities the metals remaining in MSW can be sorted which are reutilised.

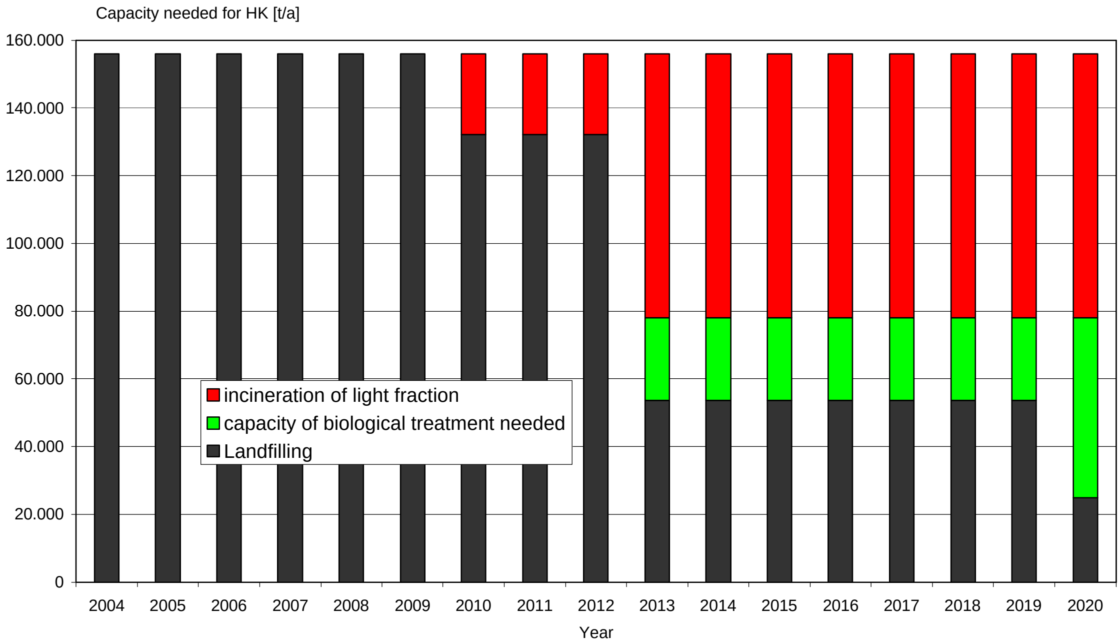
For the light fraction incineration capacities of 24.000 t/a are needed from the year 2010 and 78.000 t/a from the year 2013.

From the year 2013 capacities are needed for biologic degradation of an input of 25.000 t/a of heavy fraction and of 53.000 t/a from the year 2020.

Table 5 Capacities of Treatment Plants needed according Option 2a

Type of Treatment Plant	Capacity needed for the region of HK [t/a] 2004	2010	2013	2020
Conventional Incineration plant	--	--	--	--
Landfill for untreated MSW	156.000	109.000	--	--
Mechanical Pre-treatment	--	48.000	156.000	156.000
Heavy fraction		23.000	73.000	73.000
Biological degradation	--		25.000	53.000
Landfilling	--	22.000	48.000	20.000
Light fraction		24.000	78.000	78.000
Incineration	--	24.000	78.000	78.000
Landfilling	--	--	--	--
Recycling (metals)	--	1.000	5.000	5.000
Total	156.000	156.000	156.000	156.000

Figure 16 Capacities of Treatment Plants needed according Option 2a



Following the results of the calculations the following waste streams can be drawn.

Figure 17 Flow chart for MSW according Option 2a

5.3.3. Capacities of Treatment Plants needed according Option 2b

According option 2b a capacity of 25.000 t/a of mechanical pre-treatment plants is needed from the year 2010. From the year 2013 a capacity of 135.000 t/a is needed, from the year 2020 156.000 t/a. In such a facility residual MSW would have to be splitted in light and heavy fraction. With such splitting facilities the metals remaining in MSW can be sorted which are reutilised.

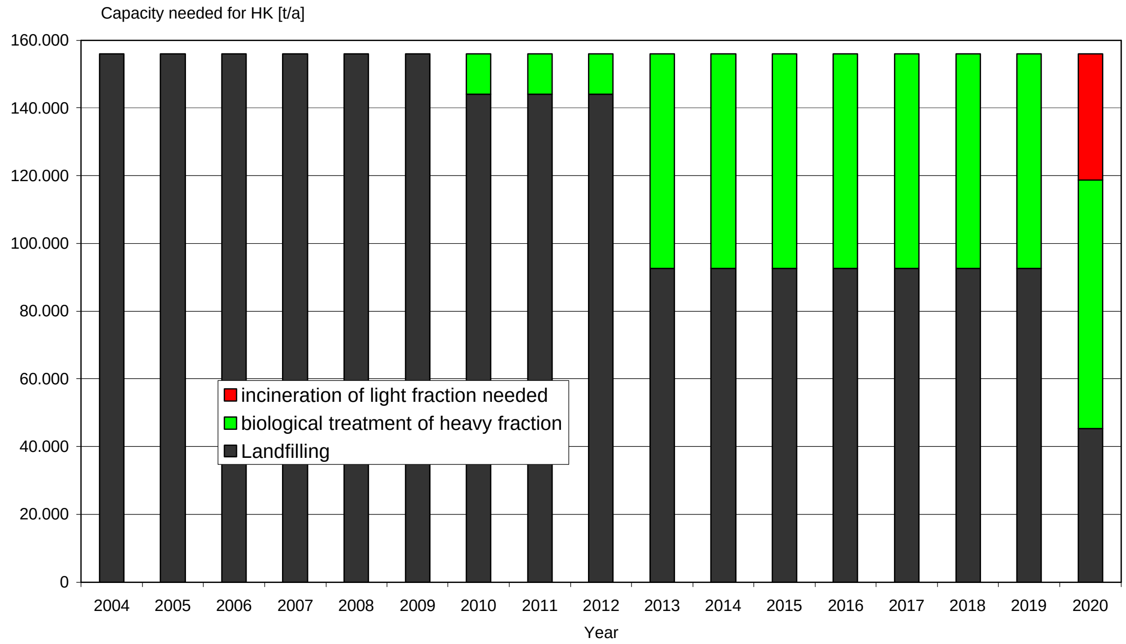
For the heavy fraction biologic treatment plant with capacities of 12.000 t/a are needed from the year 2010, of 64.000 t/a from the year 2013 and of 73.000 t/a from the year 2020.

Capacities for incinerating parts of the light fraction are needed to meet the reduction targets for BRKO-landfilling of the year 2020.

Table 6 Capacities of Treatment Plants needed according Option 2b

Type of Treatment Plant	Capacity needed for the region of HK [t/a]			
	2004	2010	2013	2020
Conventional Incineration plant	--	--	--	--
Landfill for untreated MSW	156.000	131.000	21.000	--
Mechanical Pre-treatment	--	25.000	135.000	156.000
Heavy fraction Biological degradation Landfilling	 -- --	12.000 12.000 --	64.000 64.000	73.000 73.000
Light fraction Incineration Landfilling	 -- --	13.000 13.000	67.000 67.000	78.000 37.000 41.000
Recycling (metals)	--	1.000	4.000	5.000
Total	156.000	156.000	156.000	156.000

Figure 18 Capacities of Treatment Plants needed according Option 2b



Following the results of the calculations the following waste streams can be drawn.

Figure 19 Flow chart for MSW according Option 2b

5.3.4. Capacities of Treatment Plants needed according Option 2c

According option 2c a capacity of 16.600 t/a of mechanical pre-treatment plants is needed from the year 2010. From the year 2013 a capacity of 88.000 t/a is needed, from the year 2020 128.000 t/a. In such a facility residual MSW would have to be splitted in light and heavy fraction. With such splitting facilities the metals remaining in MSW can be sorted which are reutilised.

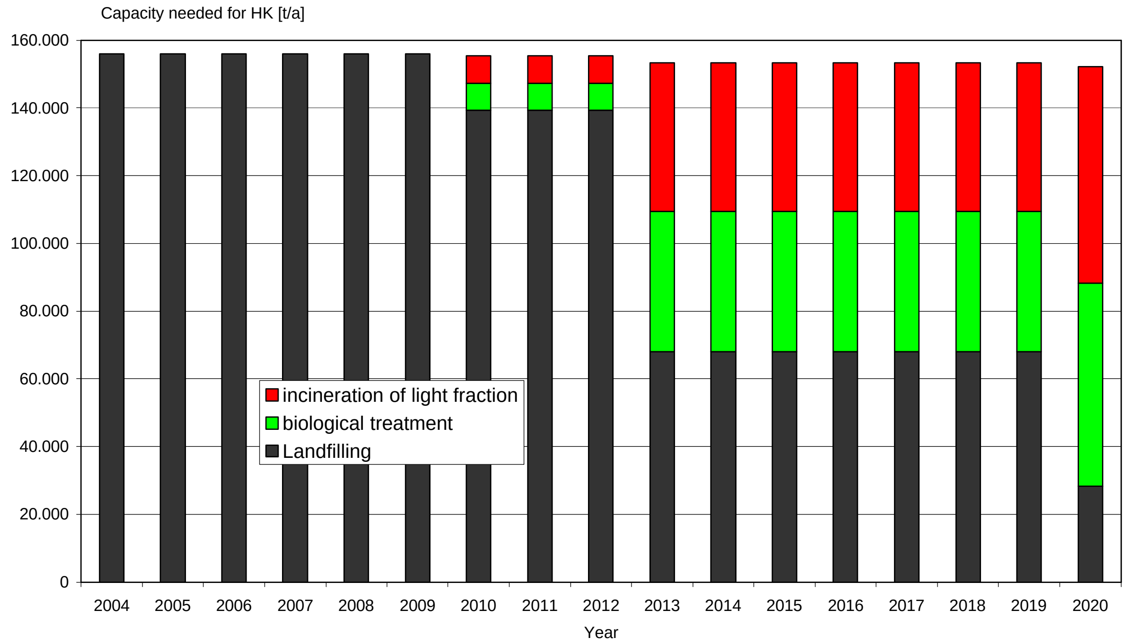
For the heavy fraction biologic treatment plant with capacities of 7.800 t/a are needed from the year 2010, of 41.000 t/a from the year 2013 and of 60.000 t/a from the year 2020.

For the light fraction incineration capacities of 8.300 t/a are needed from the year 2010, of 44.000 t/a from the year 2013 and of 64.000 t/a from the year 2020.

Table 7 Capacities of Treatment Plants needed according Option 2c

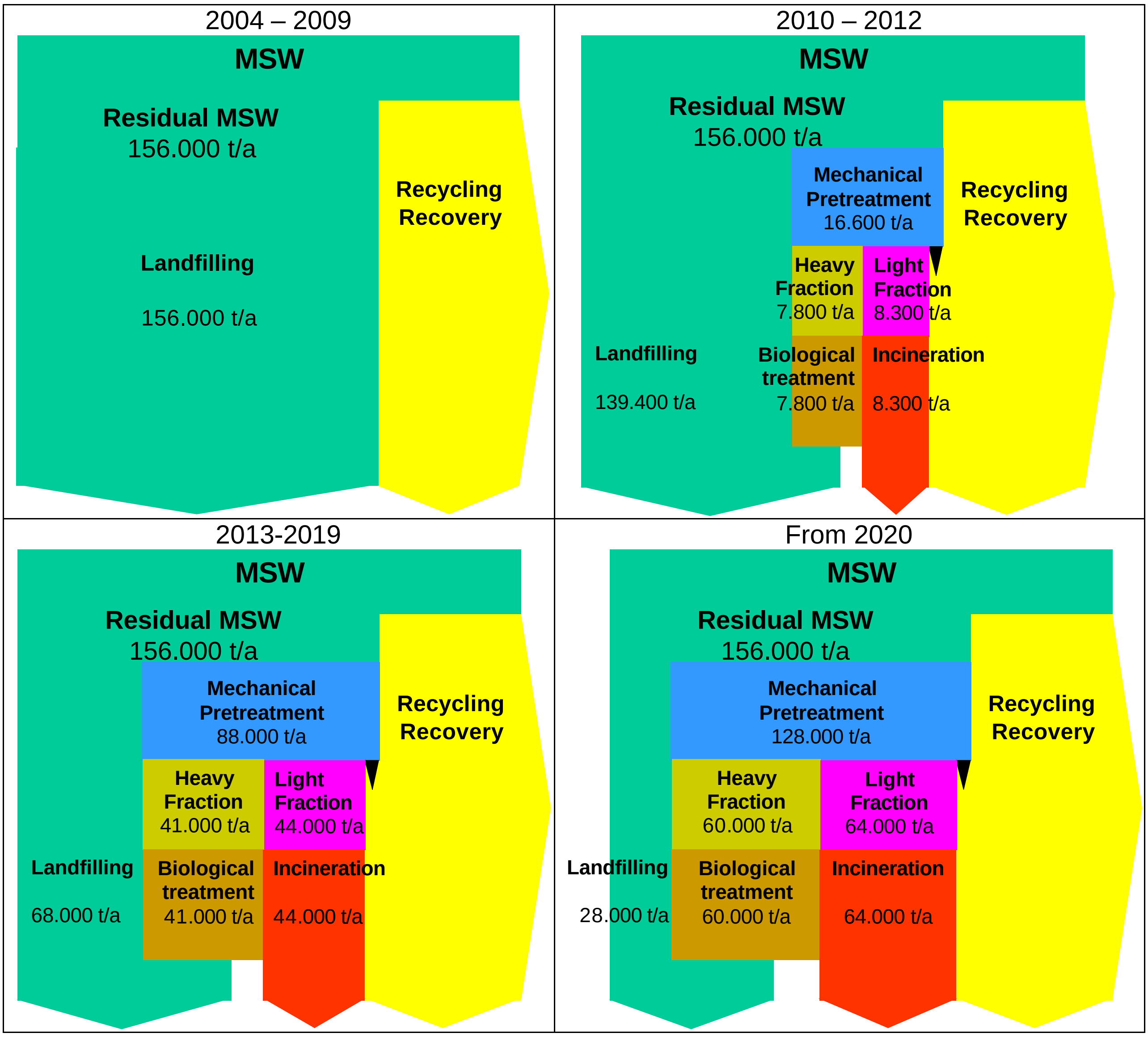
Type of Treatment Plant	Capacity needed for the region of HK [t/a]			
	2004	2010	2013	2020
Conventional Incineration plant	--	--	--	--
Landfill for untreated MSW	156.000	139.400	68.000	28.000
Mechanical Pre-treatment	--	16.600	88.000	128.000
Heavy fraction		7.800	41.000	60.000
Biological degradation	--	7.800	41.000	60.000
Landfilling	--	--		
Light fraction		8.300	44.000	64.000
Incineration	--	8.300	44.000	64.000
Landfilling	--	--	--	--
Recycling (metals)	--	500	3.000	4.000
Total	156.000	156.000	156.000	156.000

Figure 20 Capacities of Treatment Plants needed according Option 2c



Following the results of the calculations the following waste streams can be drawn.

Figure 21 Flow chart for MSW according Option 2c



6. Feasibility check of a Co-operation with the Region of Pardubice

The regions of Hradec Králové and Pardubice have similar structures. The centres of the two regions are located very close together. The distance between the two capital towns is just a little bit more than 20 km.

For a possible cooperation between these two regions the following three options are considered for a rough feasibility check. These options are:

- Option 1 - Conventional Incineration plant for residual MSW
- Option 2c - Mechanical treatment as few as needed, incineration of the light fraction and biologic treatment of the heavy fraction
- A combination of options 1 and 2c

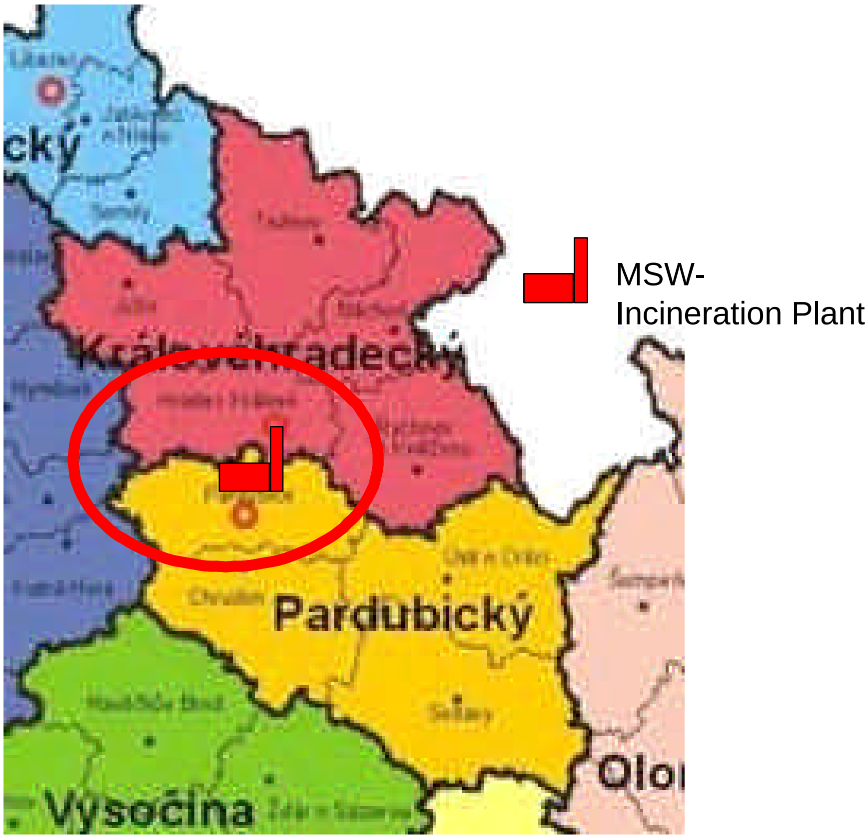
The three options are presented in the following chapters with the focus on the possible co-operation of the two regions.
In the later presented assessment all options described above and the combined option 1+2c are considered.

6.1. OPTION 1 - CONVENTIONAL INCINERATION PLANT FOR RESIDUAL MSW

As described earlier option 1 is a conventional incineration plant. Meeting the requirements for the period 2013 to 2019 a capacity of about 85.000 t/a is needed for the region of Hradec Králové. Under consideration of a cooperation with the region of Pardubice a capacity of about 170.000 t/a would be needed.

In that option primarily MSW from the central area including the town of Hradec Kralove and the town of Pardubice (a region with app. 630.000 inhabitants) would be incinerated in a new facility at Opatovice. MSW from other parts of the both regions would be landfilled further.

Figure 22 Possible catchment area for MSW-Incineration plant following Option 1



6.2. OPTION 2C - MECHANICAL TREATMENT AS FEW AS NEEDED, INCINERATION OF THE LIGHT FRACTION AND BIOLOGIC TREATMENT OF THE HEAVY FRACTION

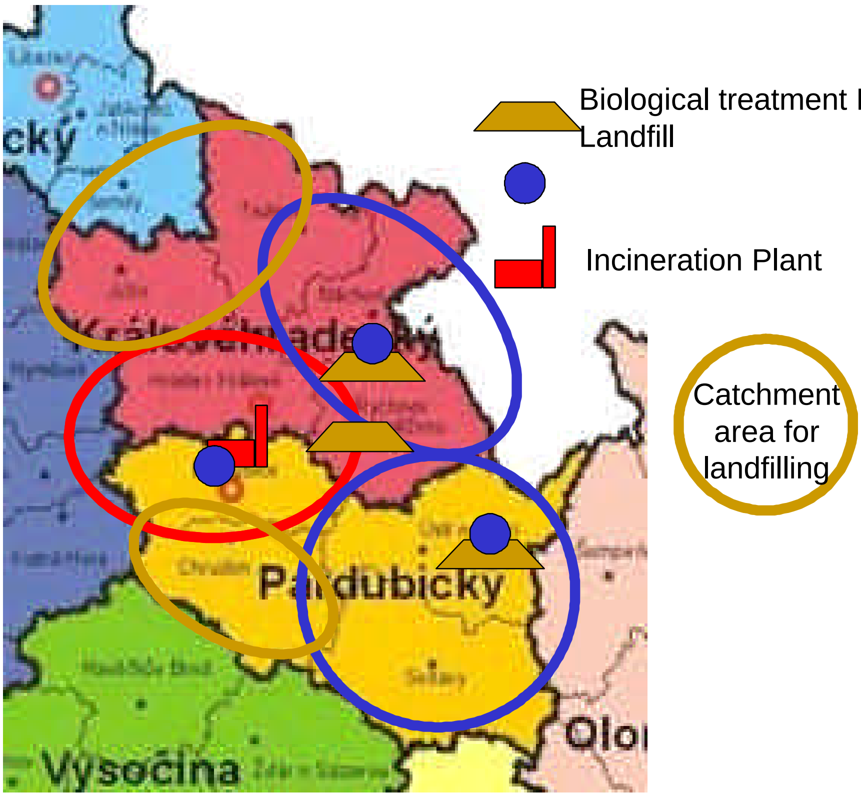
In the case of a mechanical treatment and following thermal and biological treatment of the output streams with the following capacities the requirements could be met. The plants listed in the following table are facilities which are potentially suitable to be equipped with the additional plants. Biological treatment plants would be located at existing landfills which have enough capacity to be used for the biologically treated heavy fraction for a large number of years.

Location	Type of plant	Capacity
Opatovice	Mechanical treatment Incinerator for light fraction	80.000 t/a 85.000 t/a
Ceské Libchavy (near Ceska Trebová)	Mechanical treatment Biological treatment	45.000 t/a 22.000 t/a
Kryblice (near Trutnov)	Mechanical treatment Biological treatment	45.000 t/a 22.000 t/a
Chvaletice	Biological treatment of heavy fraction from Opatovice	40.000 t/a

The location of any incineration plant is proposed to be at Opatovice, where the infrastructure for use of both heat and electricity is already available. There are however alternatives such as the existing power station at Chvaletice. None of these however appears to offer the same combination of advantages as the Opatovice site.

Considering the additional need for a disposal capacity of sewage sludge and for commercial waste the capacity for the incineration plant should be planned with 90.000 – 100.000 t/a.

Figure 23 Possible catchment areas for different types of MSW disposal plants following Option 2c



6.3. COMBINATION OF OPTIONS 1 AND 2C

This combined option considers the short transport distances of the towns of Hradec Králové and Pardubice to the planned facility in Opatovice and considers a transport optimisation. Further the system could be realised modular with the increasing requirements.

The combined option considers a classical incineration plant for MSW which should be delivered from the towns of Hradec Králové and Pardubice and the central area around these two towns. From these areas the collection vehicles could deliver directly and no transfer stations are needed.

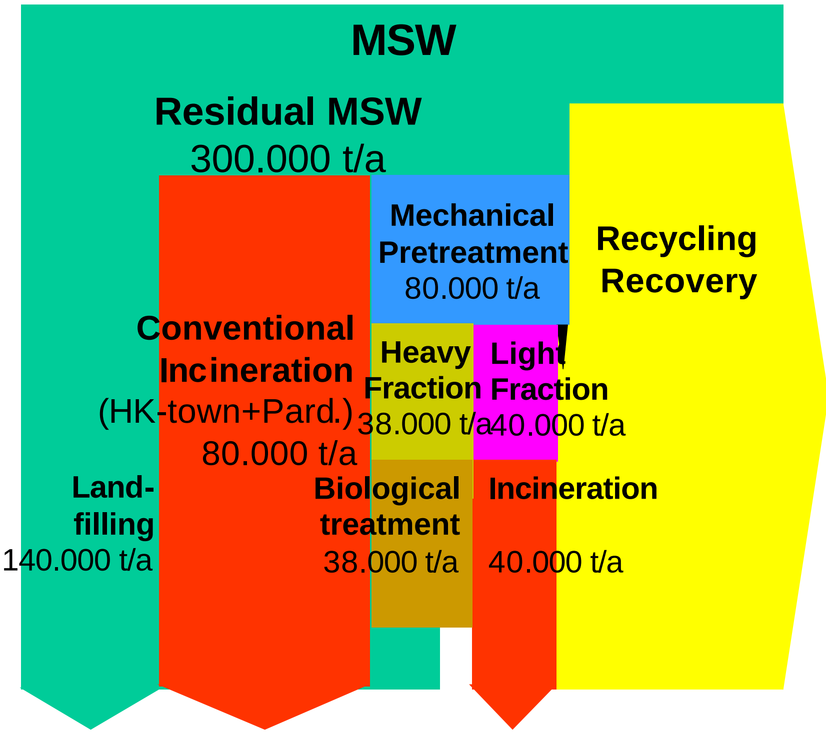
Taking into consideration the whole central area including small parts of the region of Stredoceský the capacity should be at about 80.000 – 100.000 t/a

The additionally needed treatment would be done by mechanical-biological-thermal treatment following option 2c.

The different parts of the whole system could be realised at different times, e.g. following the increasing requirements for treatment from the Landfill Directive.

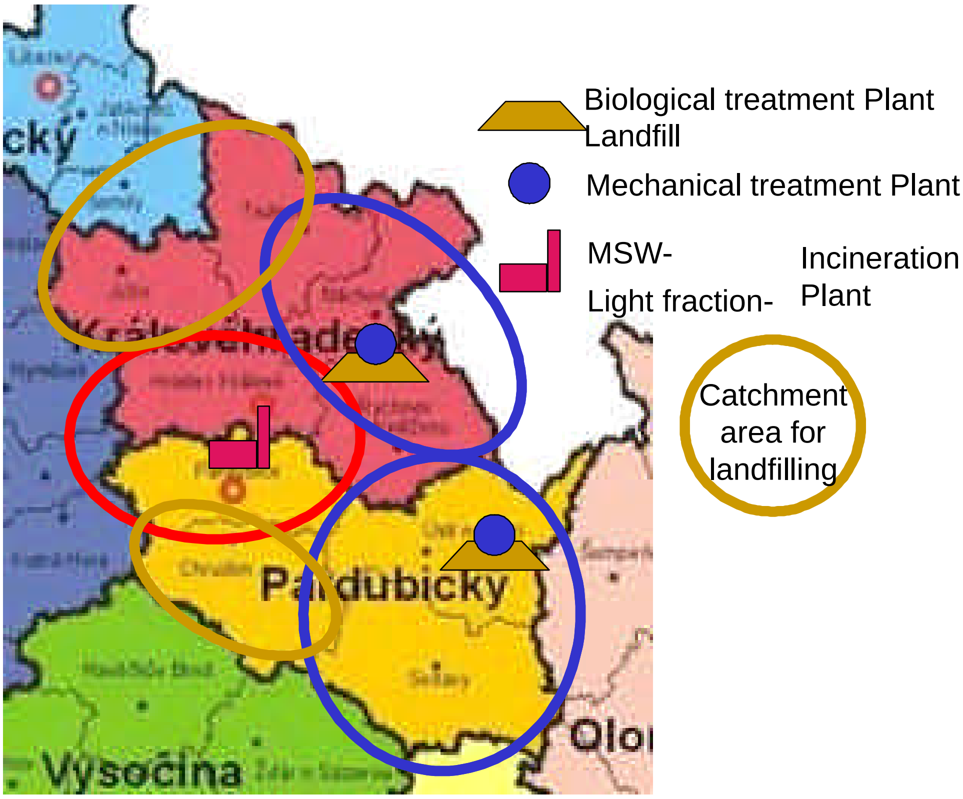
The combined option can be explained by the following picture. The figures in the picture consider the whole catchment area of this waste management system which involves both regions – Hradec Králové and Pardubice.

Figure 24 Flow chart for MSW according combined Option (1+2c) for both regions Hradec Králové and Pardubice



Considering existing facilities the catchment areas of the different types of plants could be as shown in the following picture. The red marked area would be approximately the area from which the waste would be incinerated in a classical MSW incineration plant. It could be delivered directly by the collection vehicles. The blue marked areas could be the catchment area for two mechanical and biological treatment plants. The incineration of the light fraction would take place at Opatovice.

Figure 25 Possible catchment areas for different types of MSW disposal plants following the combined Option (1+2c)



7. Assessment of Options

In this chapter the options are assessed by the following parameters:

- Legal compliance
- Economic effects
- Ecologic effects

Further a short risk assessment is done

The comparison and assessment of the options is done with the requirements of the EC landfill directive to be met from the year 2013.

The assessment considers the treatment and disposal of remaining MSW. This is MSW reduced by means of separate collection which is to be disposed by the responsible municipality.

7.1. LEGAL ASSESSMENT

The five options have been built under the frame conditions given by the EC landfill directive concerning the quantity of landfilled biodegradable MSW. So with all options these regulations are fulfilled.

The waste management hierarchy demands recovery of waste. From residual MSW which is left after all methods of separate collection and recycling energy can be recovered. This waste management hierarchy is defined in all levels of legislation.

Energy recovery is done by all options with exception of option 2b.

The biological treatment is calculated to be done in such a quality that the strong landfilling regulations of Germany and Austria would be fulfilled. The EC landfilling directive does not require such stringent quality parameters of the material landfilled.

7.2. ECONOMIC ASSESSMENT

The following table gives an overview of the results of a detailed cost accounting. This cost accounting is documented in a calculation table (in MS Excel format) which is not part of this report.[6]

7.2.1. Basic Figures of the compared options

The cost accounting done as a tool for the economic assessment starts from defined basic figures which are the same for all options assessed. These figures are shown in the following table:

Table 8 Basic figures for the economic assessment

Factor	Figure	Remark / explanation
Costs for Landfilling Residual MSW Biological stabilized heavy fraction Slag Filter ash	 800 Kc/t 600 Kc/t 600 Kc/t 4.300 Kc/t	It is assumed that the landfill tax as a tax of municipalities which comes back to it as responsible bodies for MSW has not to be considered (it has been done in the sensitivity analyses). Thermal (slag) and biological stabilized waste is calculated with the same needs at landfills and so calculated with the same costs.
Long distance Transport Costs Payload Average distance Average fuel consumption	 120 Kc/km 20 t 50 km 30 l/100 km	Short distance transports which are done with collection vehicles are not considered.
Energy revenues Heat Electricity	 0.60 Kc/kWh 0.95 Kc/kWh	The calculations are done with heat recovery. It is assumed that all utilizable heat (heat content of the waste multiplied by the efficiency of the vessel) can be sold. Utilization of heat only for production of electricity is calculated in the sensitivity analyses.
Calorific value Residual MSW Light fraction Heavy fraction	 9.0 MJ/kg 11.0 MJ/kg 7.0 MJ/kg	
Interest rate	5%	Used to calculate the cost of capital.

6 The calculation table is however an output of the Twinning Project “Financing Tools to implement Acquis in the Environment Sector”.

Factor	Figure	Remark / explanation
Depreciation periods		
Civil works	25 years	
Plant and Equipment	15 years	
Mobile Equipment	8 years	
Material flow		
Slag from incineration of MSW	30 % by mass	
Slag from incineration of light fraction	15 % by mass	
Residuals from flue gas cleaning	1 % by mass	
Ferrous scrap from incineration and mechanical treatment	3 % by mass	
Losses in biological process of heavy fraction	33 % by mass	Mainly CO_2 and water

Profit
All calculations do not consider profits of the operators. Interest rates consider only the common interest rates which have to be paid for loans.

Transport
The costs for transport concern all long distance transports. Transports with the collection vehicles are not calculated and compared. These transports are part of the collection and are similar in all options.

Biological Treatment
The biological treatment considered in the cost accounting is a facility according to the state of the art. It includes a closed rotting process, waste air collection, waste air treatment and is intended to meet the strongest requirements for the quality of the output material like existing in Germany and Austria. These requirements are much more challenging than the requirements of the EC Landfilling directive.

The calculations do not consider existing infrastructure or machinery which may exist at different sites

Best available technology
As described above for the biological treatment all plants are calculated to require the best available technology. The plants considered in the calculation are according to the state of the art. Divergences from the best available technology are calculated in the sensitivity analyses (use of slag as construction material, more simple biological treatment, only production of electric energy without other utilization of heat)

7.2.2. Results of Cost Accounting

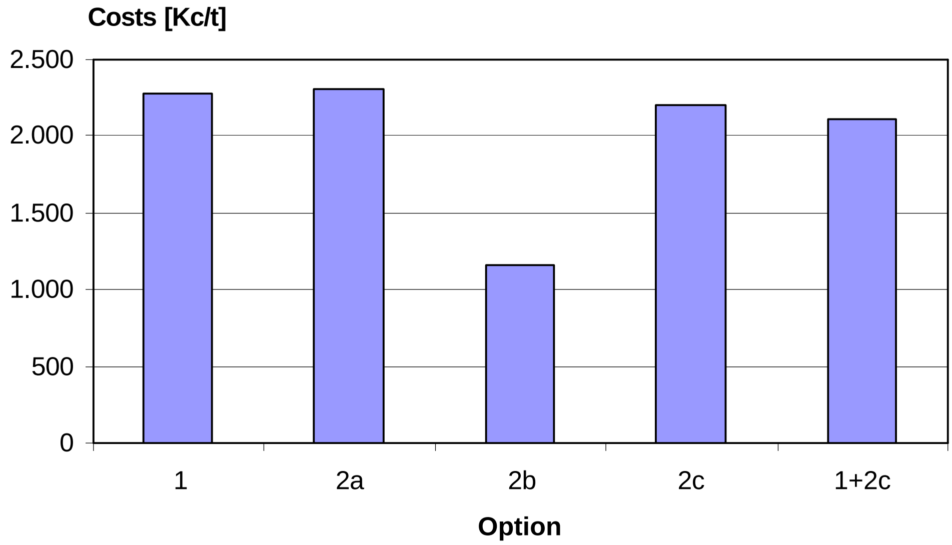
The following table shows the results of the cost accounting.

Table 9 Cost for MSW-disposal following the five options

		Thermal	MBT	Transport	Therm+MBT	Landfilling	Total	
Option 1		Thermal	MBT	Transport	**Therm+MBT**	Landfilling	**Total**	
tons		165.000	0	111.150	**165.000**	135.000		
specific costs	Kc/t	2.210	1.032	111	**2.284**	800		
costs per year	Mio Kc/a	365	0	12	**377**	108	**485**	**Mio Kc/a**
							300.000	t/a
total average costs including operational costs and depreciation							**1.616**	**avg Kc/t**
investment	Mio Kc	3.136			3.136		3.136	Mio Kc
specific investment	Kc/t	19.006			19.006		10.453	avg Kc/t
Option 2a		Thermal	MBT	Transport	**Therm+MBT**	Landfilling	**Total**	
tons		150.000	300.000	150.000	**300.000**	0		
specific costs	Kc/t	2.220	1.156	83	**2.308**	0		
costs per year	Mio Kc/a	333	347	13	**692**	0	**692**	**Mio Kc/a**
							300.000	t/a
total average costs including operational costs and depreciation							**2.308**	**avg Kc/t**
investment	Mio Kc	3.338	1.281		4.618		4.618	Mio Kc
specific investment	Kc/t	22.250	4.269		15.394		15.394	avg Kc/t
Option 2b		Thermal	MBT	Transport	**Therm+MBT**	Landfilling	**Total**	
tons		0	260.000	0	**260.000**	40.000		
specific costs	Kc/t		1.156	0	**1.156**	800		
costs per year	Mio Kc/a	0	301	0	**301**	32	**333**	**Mio Kc/a**
							300.000	t/a
total average costs including operational costs and depreciation							**1.109**	**avg Kc/t**
investment	Mio Kc		1.110		1.110		1.110	Mio Kc
specific investment	Kc/t		4.269		4.269		3.700	avg Kc/t
Option 2c		Thermal	MBT	Transport	**Therm+MBT**	Landfilling	**Total**	
tons		80.000	165.000	120.000	**165.000**	130.000		
specific costs	Kc/t	2.220	1.032	120	**2.196**	800		
costs per year	Mio Kc/a	178	170	14	**362**	104	**466**	**Mio Kc/a**
							300.000	t/a
total average costs including operational costs and depreciation							**1.554**	**avg Kc/t**
investment	Mio Kc	1.780	704		2.484		2.484	Mio Kc
specific investment	Kc/t	22.250	4.269		15.057		8.281	avg Kc/t
Option 1+2c		Thermal	MBT	Transport	**Therm+MBT**	Landfilling	**Total**	
tons		120.000	80.000	40.000	**170.000**	140.000		
specific costs	Kc/t	2.283	1.032	40	**2.107**	800		
costs per year	Mio Kc/a	274	83	2	**358**	112	**470**	**Mio Kc/a**
							300.000	t/a
total average costs including operational costs and depreciation							**1.567**	**avg Kc/t**
investment	Mio Kc	2.500	342		2.842		2.842	Mio Kc
specific investment	Kc/t	20.833	4.269		16.715		9.472	avg Kc/t

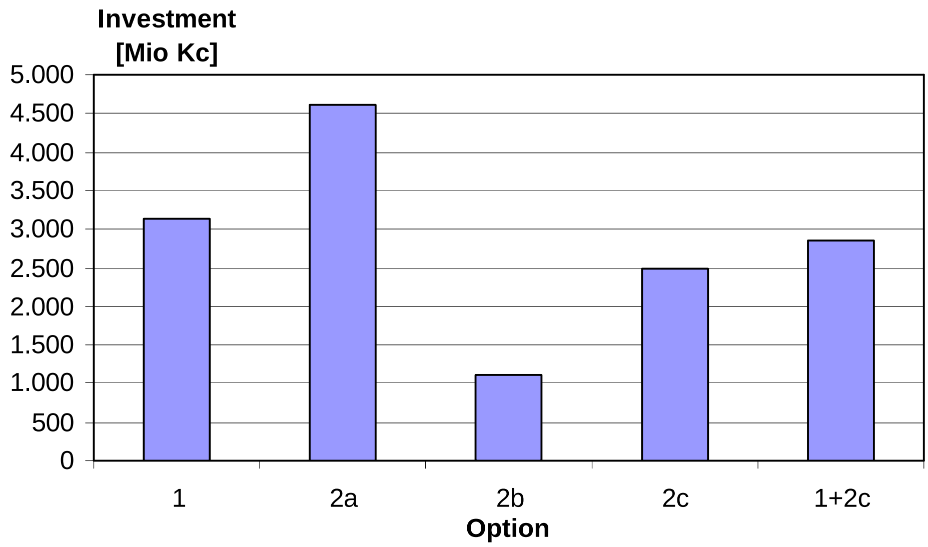
It is to be seen that option 2b is the most cheapest option. It is followed by the combined option 1+2c.

Figure 26 Comparison of Specific Costs (including operational costs and depreciation of investments)



More difference between the three options are to be seen comparing the investment costs. Option 2a needs the highest investments with about 4.5 billion Kc. The investments needed for option 1+2c are with 2.8 billion Kc about 10% lower than that needed for option 1.

Figure 27 Comparison of Investment Costs



7.2.3. Sensitivity Analyses of Cost Accounting

The results of all cost calculations are depending on the individual situation. To show how different input parameters influence the result a sensitive analyses has been done. The result of this sensitive analyse is shown in the table below. The following influencing factors have been calculated:

- **Lower revenues for energy:** The standard calculation has been done with 0.6 Kc per kWh of thermal energy. Lower revenues are calculated with 0.5 Kc per kWh of thermal energy
- **Higher revenues for energy:** The standard calculation has been done with 0.6 Kc per kWh of thermal energy. Higher revenues are calculated with 0.7 Kc per kWh of thermal energy
- **Higher transport costs:** The standard calculation considers costs for the long distance transport of 120 Kc per km. Higher transport costs are considered with 200 Kc per km. Such a scenario is realistic for instance with implementing new transport taxes. The effect of longer transport distances are also possible to be seen with the result.
- **Higher calorific value of the light fraction:** The real composition of the waste is not known. As a practical value a calorific value of 9 MJ/kg is calculated. In the case of mechanical pre-treatment the splitting of that calorific value is calculated to be 11 MJ/kg for the light fraction and 7 MJ/kg for the heavy fraction. The sensitivity analyses done considers a second scenario in which the calorific value is splitted in a wider range to 13 MJ/kg for the light fraction and 5 MJ/kg of the heavy fraction
- **Higher interest rate:** Currently interest rates are relatively low. The calculation shows the sensitivity of changes in the interest rate.
- **Longer depreciation periods:** In this line the sensitivity of the calculated depreciation periods is shown. The figures show the results when using periods two times that long than in the standard calculation.
- **More simple biological treatment:** All calculations start from the assumption of a high sophisticated biological treatment which is needed in countries where very stringent requirements concerning the biological stability of materials landfilled are in force (Germany, Austria).[7] The EC Landfilling directive does not require this standard.[8] The treatment method concerned with the “simple biological treatment” calculates with shorter biological treatment times, reflecting the less stringent requirements of the EC working document. This shorter treatment requires smaller plants with lower investment and operating costs.
- **No costs for landfilling slag from incineration:** In the standard calculation it is supposed that slag from waste incineration has to be landfilled. In this line the sensitivity is shown how the results are changing if the slag would be disposed / recovered with zero net costs.
- **Utilization of heat only for the production of electricity:** This scenario considers a situation where heat is used for producing electricity but cannot be used as heat like in a district heating system. In that case the utilizable output of electricity is calculated to be 25 % of the energy content of the waste. The revenues for electricity are calculated with 0.95 Kc/kWh
- **Kc 500 tax for landfilling:** The calculations are done without including landfill tax. This is because the tax returns to the municipalities and the State Environmental Fund. If however this tax - which could be understood as a proxy for the “environmental costs” of landfilling - is calculated for all materials landfilled the effect is shown in this line.

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7 Landfilling Regulation of the Republic of Austria in the version of BGBl. No. 49/2004, Appendix 1, Table 8 gives a stability parameter: The respiratory activity after four days (AT_4) has to be below 7 mg O_2/g dry matter. Further a limit for the calorific value is given in appendix 5 at 6,000 kJ/kg

8 The value documented in the EC working document “Biological Treatment of Biowaste” from February 2001 for the definition of “stabilisation” of biodegradable wastes by biological treatment is 10 mg O_2/g dry matter for the respiratory activity AT_4.

Without any financial support advanced treatment methods cannot be cost competitive with landfilling. For calculating the financial support needed to reach cost competitiveness two different support rates on the investments have been calculated.

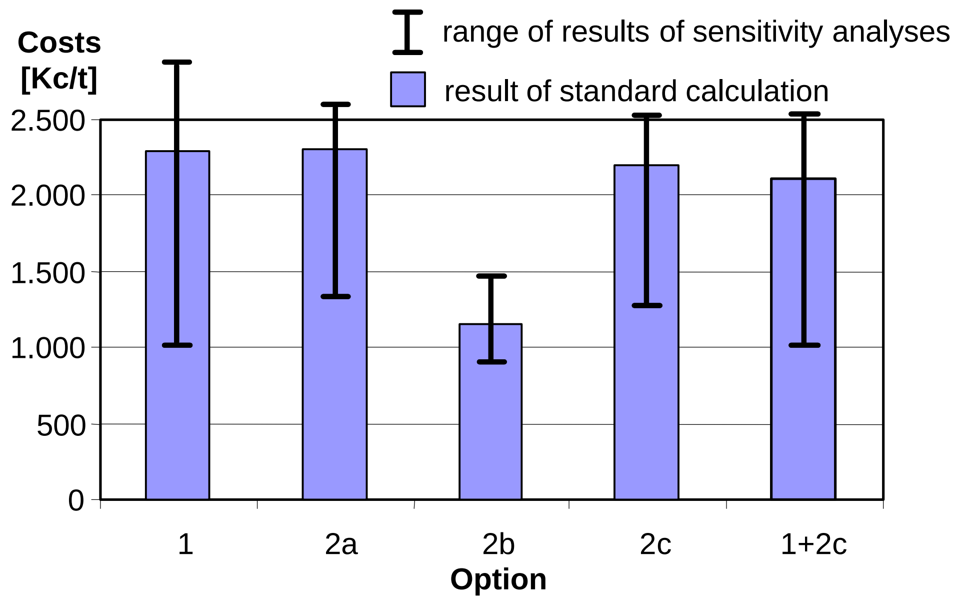
- **Support on investments 50%:** Following the approach required by the European Commission the standard calculation has considered no financial support from any source. The sensitivity analyses done shows the effect of 50% grant support (of investment costs) on the remaining specific costs.
- **Support on investments 70%:** The calculation described above has been done with a higher rate of support a second time.

Table 10 Sensitivity analyses of the cost calculation - specific costs

	Option				
	1	2a	2b	2c	1+2c
	Kc/t	Kc/t	Kc/t	Kc/t	Kc/t
Standard	2.284	2.308	1.156	2.196	2.107
energy revenue 0,5 Kc instead of 0,6 Kc	2.472	2.422	1.156	2.307	2.249
energy revenue 0,7 Kc instead of 0,6 Kc	2.097	2.193	1.156	2.084	1.965
Transport Kc/km 200 instead of Kc/km 120	2.334	2.335	1.156	2.254	2.113
calorific value of light fraction 13 instead of 11 MJ/kg	2.284	2.183	1.156	2.074	2.048
50% support on investments	1.406	1.608	963	1.512	1.341
70% support on investments	1.054	1.329	885	1.238	1.035
Interest rate 7% instead of 5%	2.544	2.520	1.215	2.403	2.336
doubled depreciation periods	1.734	1.877	1.038	1.774	1.631
Simple biological treatment (half of investment of biol part)	2.284	2.122	971	2.010	2.020
no costs for landfilling slag from incineration	2.104	2.263	1.156	2.152	2.001
heat only used for producing electricity	2.816	2.632	1.156	2.510	2.510
Kc 500 tax for landfilling (slag and MSW)	2.434	2.655	1.466	2.232	2.195

Option 2b is that one which has the lowest sensitivity to the calculated influence factors. Option 1 is that one with the highest sensitivity to changing general conditions.

Figure 28 Range of results of sensitivity analyses



The ranking of the options show in all cases cost advantages of option 2b. The second best option from an economic view is the combined option 1+2c. It is only beated by option 2c in the case of making the biological treatment more simple than calculated in the standard and the other cases.

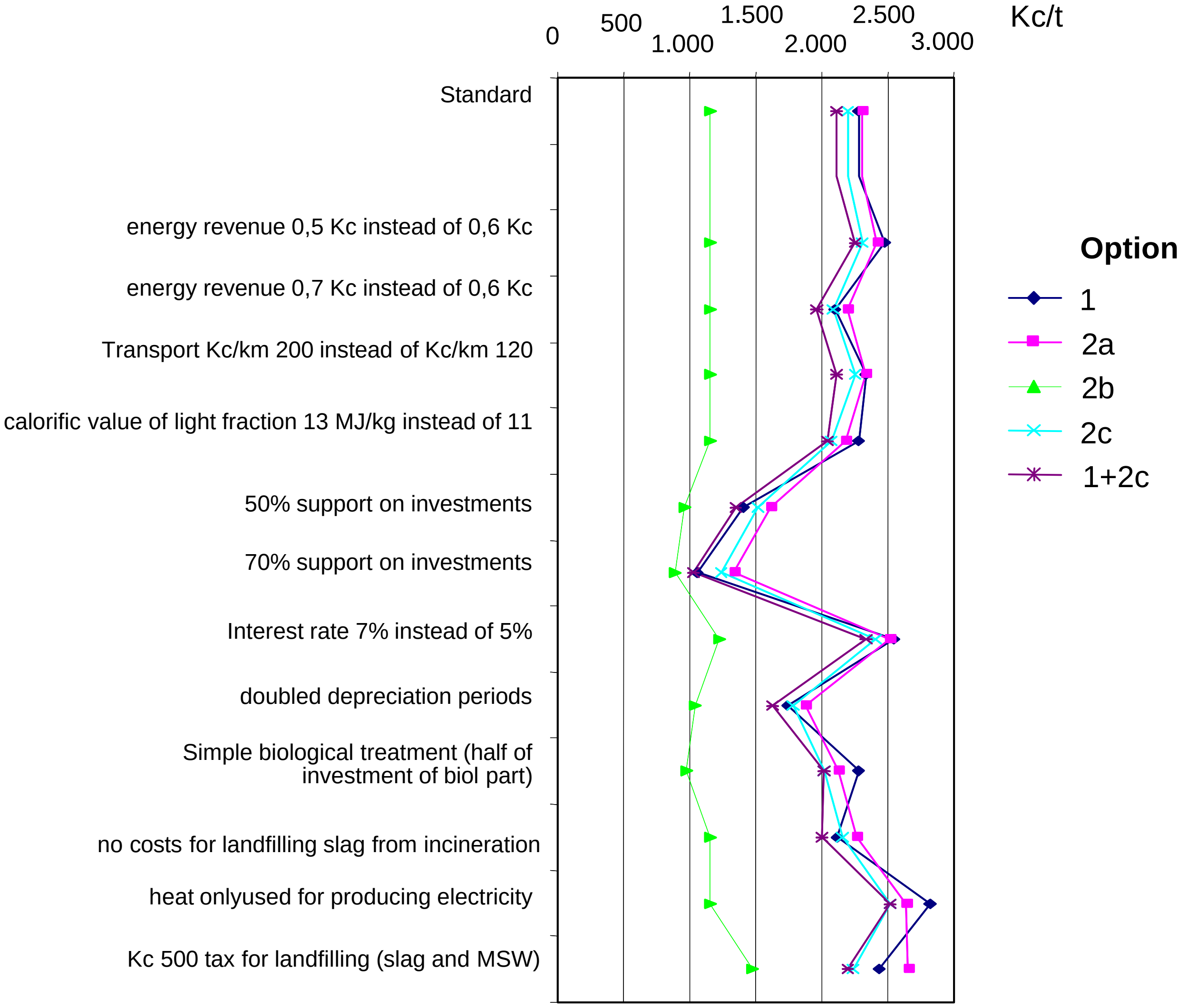
The fewest advantageous option is option 2a which is ranked at the places four and five.

Table 11 Sensitivity analyses of the cost calculation - ranking of options

	Option				
	1	2a	2b	2c	1+2c
	ranking	ranking	ranking	ranking	ranking
Standard	4	5	**1**	3	2
energy revenue 0,5 Kc instead of 0,6 Kc	5	4	**1**	3	2
energy revenue 0,7 Kc instead of 0,6 Kc	4	5	**1**	3	2
Transport Kc/km 200 instead of Kc/km 120	4	5	**1**	3	2
calorific value of light fraction 13 instead of 11 MJ/kg	5	4	**1**	3	2
50% support on investments	3	5	**1**	4	2
70% support on investments	3	5	**1**	4	2
Interest rate 7% instead of 5%	5	4	**1**	3	2
doubled depreciation periods	3	5	**1**	4	2
Simple biological treatment (half of investment of biol part)	5	4	**1**	2	3
no costs for landfilling slag from incineration	3	5	**1**	4	2
heat only used for producing electricity	5	4	**1**	2	2
Kc 500 tax for landfilling (slag and MSW)	4	5	**1**	3	2

The following figure shows the results for the different changed factors. Option 2b is that one which is the cheapest with a clear distance to the other options. The costs of the other options vary in a relatively small range (the most expensive option is 10% to 30% more costly than the cheapest option).

Figure 29 Sensitivity analyses of the cost calculation



A comparison with landfill costs including landfill tax (for the year 2009) show that option 2b could be realised without increasing costs if the tax does not have to be paid for the landfilling of biologically treated waste. That means that the tax alone would be a efficient tool to avoid landfilling outside the planned waste management system.

All disposal methods including heat recovery - which is required by the waste management hierarchy - need a financial support of more than 50 % to be able to be offered for a competitive price. This under the condition that the tax would not be collected for thermally or biologically treated MSW. Without financial support the costs would increase by about the factor two in comparison to expected landfilling costs (800 Kc/t basic costs plus 500 Kc/t tax).

Table 12 Sensitivity analyses of the cost calculation - comparison with costs for landfilling including tax for landfilling untreated MSW

	Option				
	1	2a	2b	2c	1+2c
	costs compared with landfilling				
Standard	176%	178%	**89%**	169%	162%
energy revenue 0,5 Kc instead of 0,6 Kc	190%	186%	**89%**	177%	173%
energy revenue 0,7 Kc instead of 0,6 Kc	161%	169%	**89%**	160%	151%
Transport Kc/km 200 instead of Kc/km 120	180%	180%	**89%**	173%	163%
calorific value of light fraction 13 instead of 11 MJ/kg	176%	168%	**89%**	160%	158%
50% support on investments	108%	124%	**74%**	116%	103%
70% support on investments	**81%**	102%	**68%**	**95%**	**80%**
Interest rate 7% instead of 5%	196%	194%	**93%**	185%	180%
doubled depreciation periods	133%	144%	**80%**	136%	125%
Simple biological treatment (half of investment of biol part)	176%	163%	**75%**	155%	155%
no costs for landfilling slag from incineration	162%	174%	**89%**	166%	154%
heat only used for producing electricity	217%	202%	**89%**	193%	193%
Kc 500 tax for landfilling (slag and MSW)	187%	204%	113%	172%	169%

Note: With the exception of the last line it is assumed that landfill tax has to be paid only for untreated MSW. No tax is calculated for the residues of incineration (slag) and of biologically treated MSW.

7.3. ECOLOGICAL ASSESSMENT

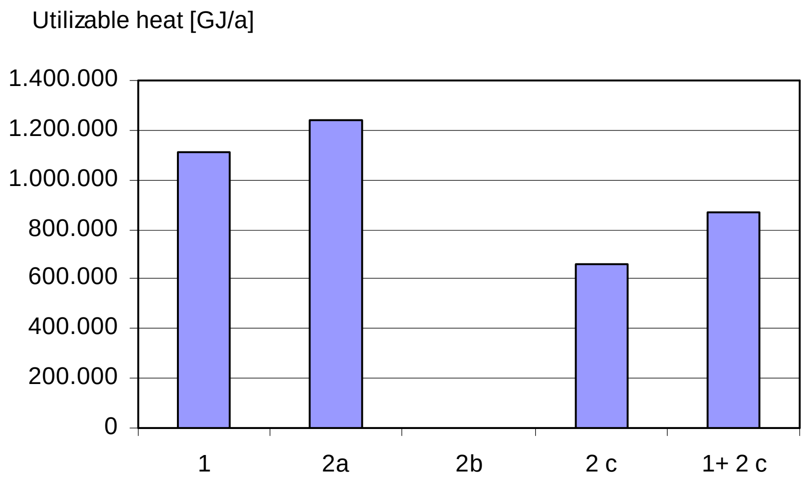
7.3.1. Energy balance

As described in the legal assessment in the case of option 2b no energy of the waste would be recovered. In the case of all other options energy would be recovered. The most energy would be recovered following option 2a. The following table shows the utilizable energy in the case of the different options. The both rows in the right show the same figures for a higher calorific value of the light fraction.

Table 13 Comparison of Utilizable Energy

Option	Utilizable heat [GJ/a]	Share of total energy content	Utilizable heat [GJ/a] LF=13MJ/kg	Share of total energy content	Ranking
1	1.113.750	41%	1.113.750	41%	2
2a	1.237.500	46%	1.462.500	54%	1
2b	0	0%	0	0%	5
2 c	660.000	24%	780.000	29%	4
1+ 2 c	870.000	32%	930.000	34%	3

Figure 30 Comparison of Utilizable Energy



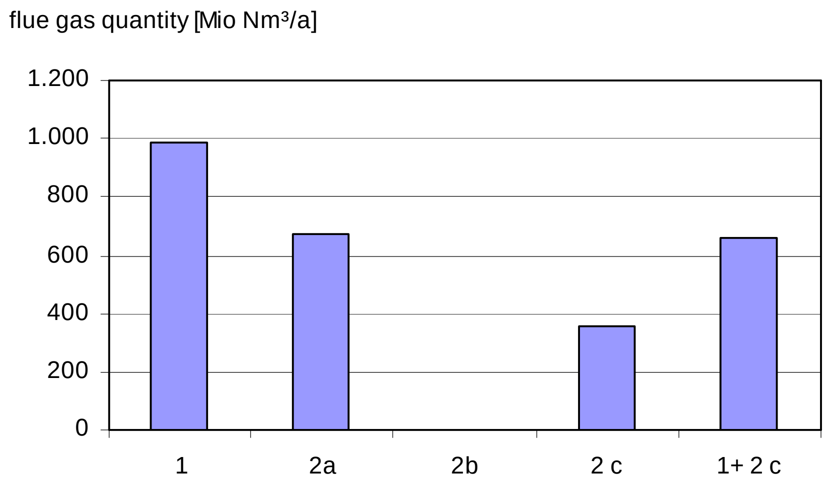
7.3.2. Emissions to the air and to ground water

In the case of waste treatment in incineration plants or in biological treatment plants the resulting gases are collected and treated according to the different regulations.

A not complete collection of gas is the case on a landfill where untreated MSW is disposed. So the quantity of not treated biodegradable content of MSW can seen as a benchmark for emissions to the air. Due to the fact that all options are designed for reducing the quantity of biodegradable parts of the MSW all five options can be seen as equal in this parameter.

Depending on the incineration technology the quantity of flue gas differs. A mass burn incinerator produces about 6,000 Nm^3 flue gas per ton of incinerated waste, a fluidised bed incinerator about 4,500 Nm^3 per ton of incinerated waste. Considering the same contents of contaminants - which are limited by the incineration directive in milligram per cubic meter flue gas - the maximum transport of contaminants polluted to the environment is proportional to the flue gas quantity. The following figure compares the flue gas quantities in the case where the light fraction is incinerated in fluidised bed facilities.

Figure 31 Comparison of Flue Gas Quantity



Emissions to ground water are to be awaited primarily by the degradation of biodegradable waste in landfills. As explained above this effect is the same in all five options.

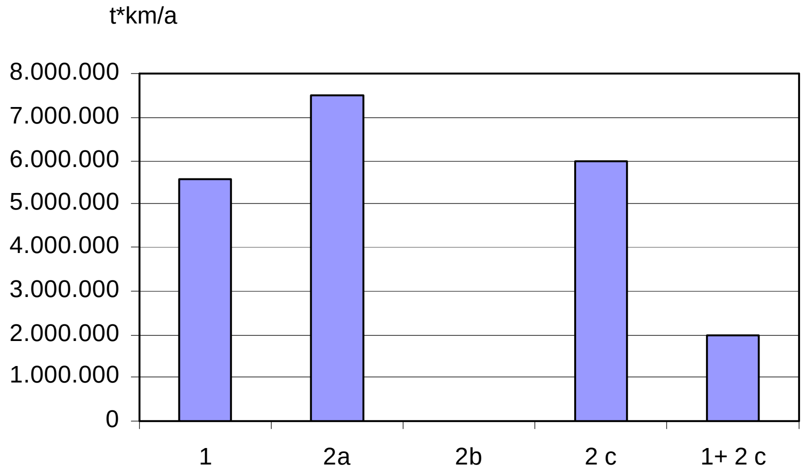
7.3.3. Transport

The transport assessment concerns all long distance transport. Transport by collection vehicles are not calculated and compared. These transports are part of the collection and are similar in all options. Option 2b needs no - or nearly no - long distance transport. This because of the calculated situation of MBT-plants at the current existing landfill sites. Most transport is needed for option 2c. The transports are calculated in tonnes transported waste times kilometres transport distance. For all options an average transport distance of 50 km for each long distance transport is calculated.

Table 14 Comparison of Long Distance Transport

Option	Distance [km]	quantity [t]	t*km/a	Ranking
1	**50**	111.150	5.557.500	3
2a	**50**	150.000	7.500.000	5
2b	**50**	0	0	1
2 c	**50**	120.000	6.000.000	4
1+ 2 c	**50**	40.000	2.000.000	2

Figure 32 Comparison of Long Distance Transport



The energy needed for the long distance transport is fewer than one percent of the utilized energy.

7.4. RISK ASSESSMENT

In the following chapter a list of possible risks is listed and the sensitivity of the assessed options to unexpected changes in the general conditions are described.

Key risks include:

- Changing Quantities of MSW
- Changing composition of MSW
- Unexpected development of separate collection
- Planned and unplanned standstills of single facilities of the disposal system
- Unexpected change of national legislation
  - Landfill taxes
  - Calculation method of biodegradable content of MSW (BRKO)
- No/little agreement/cooperation between different investors/operators of facilities within one option (equals a waste management system)

7.4.1. Changing Quantities of MSW

Quantities of MSW can develop to a much higher or a much lower level than expected.

Considering the fact that all options calculating with waste which is landfilled without treatment a decreasing quantity of MSW would reduce landfilling and would have the effect of over-fulfilled requirements because the share of not treated residual MSW decreases.

In the case of a much more increasing quantity of residual MSW additional treatment facilities are needed. Such facilities can be built relatively independent from the existing waste management system. Especially mechanical and biological treatment facilities need no other infrastructure.

7.4.2. Changing Composition of MSW

Concerning incineration facilities the calorific value is the most important figure. If it increases more than expected the capacity of the incineration plants decreases. This guides to the same effects as described above if the waste quantity rises more than expected.

7.4.3. Unexpected development of separate collection

Separate collection influences the quantity as well as the composition of the remaining MSW. Both effects are described above.

7.4.4. Planned and unplanned unavailability of single facilities of the disposal system

A system is the more complex the more connections are between different parts of the system. The complexity of a system makes it more stable than a system with one or few parts. For the waste management system it means that systems with one single treatment facility like described under option 1 are more liable to single breakdowns or outages than systems which are operating as a network and where different parts can change capacities.

As described above in each option are enough capacities available to take capacities from other facilities. In the case of an unplanned standstill of a mass burn incinerator (especially option 1) it is possible that the requirements given by the Landfill Directive cannot be met in the period in which the facilities are not in operation.

7.4.5. Unexpected change of national legislation

7.4.5.1 Landfill taxes

The higher future landfill taxes for landfilling untreated waste the more advantageous are treatment activities.

7.4.5.2 Calculation method of biodegradable content of MSW (BRKO)

The calculation method of BRKO intends an increasing share of biodegradables in the residual MSW. In the future the composition of waste will be known much better than today. In the case of a well known composition the importance of calculation methods decreases. If the increase in the BRKO content will not take place than to be calculated currently the requirements of the EC landfill directive can be met more easy. In that case the requirements are over-fulfilled with the calculated capacities. In because of the hard increase to be calculated it is not to be expected that the increase in BRKO share will be higher than calculated.

7.4.6. No/little agreement/cooperation between different investors/operators of facilities within one option

Waste management systems like described for options 2 a,b,c consist of facilities owned and operated by different institutions / companies. For the functioning of the system a cooperation between the different parts of the system / network is essential.

In fact there is a clear trade-off between this risk and the one described above in Section 7.4.4 above: option 1 has lower risks in terms of the cooperation needed with other parties (because there is only one major new investment), but greater risks in the event that the incinerator is unavailable for technical reasons; the other options are less reliant on the incinerator in the event of its non-availability, but are more demanding in terms of the cooperation needed with other parties.

7.5. OVERALL RANKING

Adding the results of the different assessments to one table a clear ranking of the option can be seen. The ranking in all three parts of the assessment is very similar. So it is no needed to give different parts of the assessment different weights. The ranking is as follows:

1. Combined option 1+2c
2. Option 2c
3. Option 1
4. Option 2a
5. Option 2b is not in compliance with the waste management hierarchy

Table 15 Overall ranking of the options

	Option				
	1	**2a**	**2b**	**2c**	**1+2c**
Legal assessment	1	1	Not compliant	1	1
Economic assessment	4	5	1	3	2
Environmental assessment	3	3	1	3	2
Utilizable energy	*2*	*1*	*5*	*4*	*3*
Emissions to air	*5*	*4*	*1*	*2*	*3*
Transport	*3*	*5*	*1*	*4*	*2*
Risk assessment	No special disadvantages				
Total	**3**	**4**	**Not compliant**	**2**	**1**

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