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Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Umwelt Bundes Amt
Für Mensch und Umwelt

# Draft National Strategy

FKZ 380 01 109

## Development of a national strategy for reducing the quantities of biodegradable waste constituents for deposition on landfill sites

Bulgaria

December 2005


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in co-operation with

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SGS INSTITUT FRESENIUS

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## ABBREVIATIONS

| | |
|---|---|
| BD | Bio-Degradable waste |
| BMU | German Ministry of Environment |
| EC | European Commission |
| EEA | Executive Environmental Agency |
| EMEPA | Enterprise for Management of Environmental Protection Activities |
| EU | European Union |
| IPPC | Integrated Prevention and Pollution Control |
| MAC | Maximum Allowable Concentartion |
| MBT | Mechanical-Biological Treatment |
| MOEW | Ministry of Environment and Water |
| MSW | Municipal Solid Waste |
| NSI | National Statistical Institute |
| NWMP | National Waste Management Programme |
| PCW | Paper and Cardboard Waste |
| UBA | German Federal Environmental Agency |
| WWTP | Waste Water Treatment Plant |

# 1 INTRODUCTION

To implement the European Landfill Directive 1999/31 EC it is necessary to reduce the biodegradable fraction of waste that has to be deposited on landfill sites in Bulgaria.

Therefore, a national strategy for Bulgaria has to be developed. This requires various investigations and development of concepts to cover different aspects, in order to bring them in line with already existing technical, organisational, social and legal framework conditions.

This target was to be achieved by the following work programme:

- Description of the potential of biodegradable constituents actually present in the waste.
- Inventory of the existing structures for collection and transportation of waste.
- Inventory of existing and planned treatment capacities for biodegradable waste constituents.
- Forecast of the future development of biodegradable waste constituents.
- Determination of regional reuse options for compost and sewage sludge.
- Assessment of major options for the reduction of biodegradable waste constituents according to regional and structural frame conditions, namely
  - separate collection and transformation into reusable compost;
  - inertisation (solidification & stabilisation) of remaining organic fractions in the residual waste by biological or thermal procedures.
- Transformation of results into a **national strategy for reducing the quantities of biodegradable waste constituents for deposition on landfill**.

The entire project is managed in close consultation with the local national institutions esp. the Ministry of Environment, and the German Ministry of Environment (BMU) represented by the Federal Environmental Agency (UBA), which supports this aid project.

A description of the present situation was the objective of the **Interim Report**, handed in by SGS in **June 2005.** The Interim report presented the following basic items:

- **Legislative framework** of the European Community and Bulgaria
- **Status of Bulgaria in terms of national development** (population, economy, income etc.) as far as related to the items of the project. This serves for the calculation of biodegradable waste constituents in the next years, forming the basis for the reduction required to meet the step-wise decrease of biodegradable waste constituents allowed on landfill.
- Data concerning the **origin of waste from different sources**, including a discussion on the determination of the quantity of biodegradable waste going to landfill in the year 1995, being the important reference feature for the subsequent step-by-step reduction until 2020.
- Recent status and development of **waste collection and treatment,** including specific cost incurred for waste collection and disposal.
- Data on waste water treatment and **qualities of sewage sludge,** complemented by a prognosis of future **amounts of sewage** sludge by increase of water treatment.

- **Agricultural data** in terms of cultivated crops and area and demand of fertilizers, in order to estimate the potential application and benefits from the use of compost and/ or treated sewage sludge in agriculture.
- Frame conditions for a **prognosis of the amounts of biodegradable waste constituents** and **sewage sludge** in the next years including reduction tasks.
- Coarse characterization of the **technical and administrative measures to reduce the biodegradable fraction** in municipal waste.

The details of the very chapters in the Interim Report are not repeated in this report, which is focussed on

- the **general reduction tasks**, specified in masses of biodegradable fractions in municipal waste and sewage sludge
- the more detailed description of the **administrative procedures and technical methods** to reduce biodegradable fractions in both, municipal waste and sewage sludge, with comments on the adaptability of the measures on different dwelling structures.
- the **stepwise implementation program** for the different measures; making use of less cost-intensive measures at the first instance, and later complemented by more cost-intensive measures.

As described in the interim report, the situation in Bulgaria is characterized as follows:

- The far dominating portion of all wastes are brought on landfill;
- Recycling and pre-treatment activities are on a low level;
- The data basis provided by the communities concerning different waste streams is weak and partly not consistent, this applies to both, masses and morphology;
- Detailed research concerning waste masses and morphology of different provenience has just started.

On this background it has to be understood that - at present - it cannot be defined *precisely*, which measure of reduction will come to which result. Nonetheless, a couple of measures can be recommended, being sure that they are both, effective and not too costly.

To this respect, this report develops a frame of reasonable measures at a *nationwide* scale are developed in this report. Whilst observing the implementation of first measures, specific investigations on waste are carried on and experience on administrative, technical and financial aspects are gathered in order to decide on allocation, methods and extend of the next steps.

Based on the present status and the established prognosis including various inaccuracies, this study comprises the development of a **calculation tool for biodegradable waste management**, enabling MOEW to simulate specific scenarios, taking into account the experiences of implemented pilot measures and further research studies.

# 2 FRAME CONDITIONS FOLLOWING EU LANDFILL-DIRECTIVE

To calculate the total reduction demand for the years up to 2020, four main figures are finally important:

a) The basic mass of biodegradable waste in 1995

b) The already achieved status now (2004) as the basis for further activities

c) The reduction targets according to EU ( 25 %, 50 %, 65 %), compared to the basic mass in 1995

d) The forecasted (increased) amount of biodegradable waste in the "critical" years 2010, 2013 and 2020

A general survey is given in

**Table 1**.

***Important note:*** *The EU - Landfill directive and the EUROSTAT-data for biodegradable waste ("BD") just cover biodegradables in municipal solid waste, not sewage sludge. Following this formal agreement,* ***sewage sludge is excluded*** *from this calculation and from the concept for reduction as well. Nonetheless it is obvious that sewage sludge has a high biological reactivity in the landfill, in its negative ecological impacts comparable to those of the biodegradable fraction in solid waste. Therefore, the estimated masses of sewage sludge are included in this table, to hold the attention on it.*

**Table 1** *Amounts and needed reduction of biodegradable waste following the targets according to EU Directive until 2020*

| year | Parameter | Share of 1995 | BD of MSW Mg/a | Sewage sludge Mg/a |
|---|---|---|---|---|
| **1995** | **Start Mass Biodegradables** | 100% | **2.247.500** | not included |
| **2002/4** | Produced mass | *73%* | 1.631.679 | 299.750 |
| | **Reduction achieved compared to 1995** | | 615.821 | |
| **2010** | *Produced mass* | *72%* | 1.608.340 | 357.500 |
| | *Target EU Directive* | *75%* | *1.685.625* | |
| | **Reduction demand compared to 2004** | | **-77.285** | |
| **2013** | *Produced mass* | 71% | 1.599.811 | 397.815 |
| | *Target EU Directive* | *50%* | *1.123.750* | |
| | **Reduction demand compared to 2004** | | **476.061** | |
| **2020** | *Produced mass* | 72% | 1.614.839 | 437.597 |
| | *Target EU Directive* | *35%* | *786.625* | |
| | **Reduction demand compared to 2004** | | **828.214** | |

Gelöscht:

| year | Para |
|---|---|
| 1995 | Start |
| 2002/4 | Prod |
| | Redu |
| 2010 | Prod |
| | Targ |
| | Redu |
| 2013 | Prod |
| | Targ |
| | Redu |
| 2020 | Prod |
| | Targ |
| | Redu |

The reliability of the EUROSTAT–value for biodegradable fractions in 1995 **(point a))** has already been discussed (in the interim report), leading to the conclusion that the basic mass assumed for bio degradable fractions was too high. Nonetheless, this is likely to be neutralized, if EUROSTAT-data are projected in consequence to **point b)** as well. EUROSTAT-data show that biodegradable fractions have already decreased by more than 600.000 tons per year since 1995.

The targets of the EU–Directive **(point c))** are calculated in fixed masses of biodegradable fractions, allowed to be brought on landfill in the concerned year.

The **reduction demand** is specified by the difference between the allowed mass to be brought on landfill and the recent amount of produced biodegradable waste **(point d)).** This amount is partly known (for 2002/2004), and forecasted for 2010, 2013 and 2020. As outlined later, the amount of biodegradable in MSW will remain quite constant at 1.6 Mio tons per year. Aside, the amount of sewage sludge will increase, roughly from 300 000 Mg/a now to about 440 000 Mg/a in 2020.

Taking these values into account, no reduction is necessary until 2010, since the reduction to 75 % is already reached at present. In 2013 the reduction demand jumps up to almost 476 000 Mg/a, followed by an increase to 828.000 Mg/a in the year 2020.

As outlined later in the implementation concept, **the fact that the reduction aim for 2010 has *arithmetically* already been achieved should not lead to the conclusion that no further activities are necessary in the upcoming years.** On the one hand there are several options given to reduce biodegradable fractions in the short term which can be realized at low additional cost, leading to a significant ecological benefit. Further, experiences show that the upcoming demand for reduction of 476 000 Mg/a by 2013 cannot be realized “just-on-time”, so an at least stepwise reduction before 2013 is recommended. On the other hand, the remaining time before 2013 is certainly needed to gather specific experiences with different reduction methods and their technical and administrative characteristics, this enabling the national and local administrations to select the most effective systems and combination of reduction measures for further implementation. Finally, there is an - only formally excluded - amount of landfilled sewage sludge in 2010, with 357 000 Mg/a almost five times higher than the surplus of already achieved reduction of the biodegradable solid waste.

In this respect, **all running and planned activities to reduce biodegradable waste fractions are urgently recommended to be continued.**

In the next chapters, options for the reduction of biodegradable waste fractions are outlined. Since sewage sludge covers between 20 - 25 % of the overall amount of organics, it will be discussed separately from measures intended for the reduction of other biodegradable fractions of the MSW.

# 3 REDUCTION OPTIONS FOR BIODEGRADABLE WASTES

## 3.1 GENERAL SURVEY

The options to reduce biodegradable fractions in waste can be listed as follows:

Measures by **separate collection and treatment** of

- Municipal green yard waste
- Paper/cardboard
- Organic kitchen and garden waste ("bio-waste")
- In rural areas: Supporting the motivation for backyard composting and animal feeding of kitchen and garden waste

Measures by **treating the remaining mixed** waste

- Incineration
- Mechanical/biological (and thermal) treatment

The reduction effect, applicability and costs of these measures depend mainly **on the type of dwelling structure**.

**Figure 1** provides a survey on the frame situation and targets:

The figure depicts the influencing factors on both, the origin of biodegradable waste according to the distribution of population and their specific production of organics, the frame factors which already lead to a reduction and the measures optionally to be applied.

### Origin of biodegradable waste (Part I and II)

Recently and even more in the future, the (with about 80 %) major part of biodegradable fractions will come from the cities (including "inner city" and "suburbs"). At one hand because the major part of population is living there, at the other since the biodegradable waste fraction is very low in the rural areas.

### Existing reduction activities (Part III)

Backyard composting and animal feeding play an important role in rural areas, accompanied by burning paper apart from informal recycling (which forms part of almost all dwelling structures).

In cities with central heating systems, no or even small amounts of paper and wood are burned, thus increasing the amount of paper in the waste bin. Backyard composting is of small relevance in the inner city; in the suburbs it can principally be applied, but it is to be observed that following the trend to more comfort, organics become more and more part of the household waste.

### Activity options (Part IV)

This is a coarse review of the main options to reduce biodegradable fractions in waste, estimated with respect to their applicability in the different structures. Each of them sets a specific demand, at first achieving a reduction at low cost, while – in general – the costs increase the higher the reduction rate shall be.

The measures are described in the following chapters in their qualitative aspects. The proposals and calculations of implementation are described in chapter 3.

*I Population Data*

| | *Population 2010* | Inner City 52 % | Suburbs 21% | Rural 27 % |
|---|---|---|---|---|
| TOTAL | 7.500.000 | 3.900.000 | 1.600.000 | 2.000.000 |

*II Amounts of biodegradable waste*

| Biodegradable fractions kg/cap/year including commercial and other municipal waste | Inner city | Suburbs | Rural |
|---|---|---|---|
| | 220 | 180 | 85 |
| Contribution to Total Biodegradable-Mass | 64 % | 22 % | 14 % |

*III Existing Reduction Activities*

| | Inner city | Suburbs | Rural |
|---|---|---|---|
| Established **backyard composting** | no | low - middle | high |
| **Paper use for heating** | no - low | low | high |

*IV Activity options*

| Activities for … | Inner city | Suburbs | Rural |
|---|---|---|---|
| Separate collection of **garden waste from public parks etc**. | high | middle - high | middle |
| Separate collection of **paper** | high | high | middle |
| Separate collection of **bio-waste** | no | high | no |
| **Motivation** campaign to increase **backyard com-posting** | no | middle | high |
| Treatment of **MSW by MBT** | high | middle | low |

**Figure 1** *Overview on the frame situation and targets for reducing the organic fraction in municipal waste*

## 3.2 COLLECTION OF MUNICIPAL GREEN YARD WASTE

These are the organic residues coming from public parks, cemeteries, street trees (leaves) as well as from private enterprises taking care of the garden/park areas of their clients. The operational advantage of this organic waste fraction is that it is already collected separately by own vehicles.

Therefore, composting could be implemented as an effective first measure in the cities. Composting is quite simple, since green yard waste does not create that many emissions as compared to e.g. bio-waste. This can be accompanied by general restrictions to deliver green yard waste and/or manure to the local landfill. Of course the option must be provided to discharge green yard waste in a separate area at the landfill's entrance. Depending on the local structures, the system can be extended by providing semi-centralized containers for garden wastes from private households.

Specific masses depend – of course – on the specific green area in a structure. In general, the masses for cities can be assumed in the range of 25 – 30 kg/cap./year.

The technical process comprises of simple windrow composting, favourably on a concrete covered area, roughly to be dimensioned at 0.8 m² per ton a year (meaning that 5.000 tons per year need an area of 4.000 m²). Processing at a closed landfill is possible as well. For masses above 10.000 ton/year collected at one composting place, an own equipment with a shredder, turning machine and a mobile drum screen to refine the compost is economically feasible. Otherwise this equipment should rotate and operate on different smaller composting sites.

**Figure 2** *Green yard waste composting area*

**Figure 3** *Windrows of green yard waste composting*

**Figure 4** *Windrow turning machine*

### 2.2.1 SPECIFIC FRAME CONDITIONS IN BULGARIA

At present the waste coming from public parks, cemeteries, street trees (leaves) etc. are usually collected separately by the municipal companies, but are finally disposed at the landfill site.

Following the requirements stipulated in the National Waste Management Plan and in the Plan for the Implementation of Directive 1999/31/EC on Landfill of Waste, some of the municipalities included in their Waste Management Plans measures for separate collection of biodegradable waste, mainly by separate collection and building of central-ised composting installations for green yard waste, animal residues and other separately collected biodegradable waste.

Table 2 provides a summary of planned activities in some of the municipalities for future separate collection and treatment of bio-degradable waste. The information was obtained via questionnaires send to all municipalities.

**Table 2** *Local Composting initiatives*

| Region | Municipality | Planned measures/composting installations |
|---|---|---|
| **NW** | Mizia | Designation of sites in every city/village of the municipality for composting of organic waste and manure. |
| | Belogradchik | Implementation of a system for composting of biodegradable waste - the possibilities for applying such practices should be examined till 2008. |
| | Varshec | Projects for ccomposting and separate collection (not approved yet) |
| **NC** | Belene | Preparation of site and determination of the order for separate collection of biodegradable waste from agricultural activities. |
| | Ugarchin | Building of a regional landfill together with other municipalities in Lovech – Planned for the period 2007 - 2009. |
| | Kneja | Development of the instructions for composting of garden waste, manure and bio-products and determination of a proper site for composting. |
| | Letnica | Building of a composting installation for animal residue and other organic waste (almost ready) with planned capacity of 1 000 tons. |
| | Levski | Building of a composting installation for green yard waste and animal residues, planned capacity 10 000 tons, project submitted to EMPEA for financing. |
| **NE** | Novi Pazar | Project for composting is prepared and submitted to EMPEA for financing. |
| | Dulovo | Closing out of the village landfills and building up of dunghills. |
| | Zavet | Designation of sites for temporary storage of manure in the villages, building a regional composting installation. |
| | Smyadovo | Designation of dunghills in the villages. |
| | Provadiya | Building of composting installations. |
| | Sitovo | Construction of workshop for eco-briquettes from bio-mass and composting installation. |
| | Hitrino | Separate collection of household waste, construction of municipal center for composting of animal waste. |
| **SW** | Kostenetz | Construction of composting installation. |
| | Sofia | Project for composting of green mass from the public parks and green zones. Expected start of the project 2006 - 2007. The envisaged budget is approximately 50 000 leva. |
| | Blagoevgrad | Project for composting installation (unloading station) with planned capacity of 8 000 tones (ISPA funding, but not yet approved). |
| | Kocherinovo or Kustendil | Project for composting installation with planned capacity of 5 000 tons (ISPA funding, but not yet approved). |
| | Dupnitza | Project for composting installation (unloading station) with planned capacity of 5 000 tones (ISPA funding, but not yet approved). |
| | Bansko | Project for construction of composting installation. |
| **SC** | Strelcha | Construction of concrete platform for storage of biodegradable plant and animal waste. |
| | Bratzigovo | Defining and preparation of sites for composting of plant and animal waste in the villages of the municipality. |
| | Zlatograd | Composting installation for biodegradable waste. |
| | Topolovgrad | Construction of composting site in Oreschak village. |
| | Krumovgrad | Participation in the joined project of the municipalities of Kardjali region for construction of composting installation in Kardjali municipality. |
| | Chirpan | Construction of municipal compost center. |
| | Kuklen | Construction of composting installations. |
| | Momchilgrad | Construction of overloading station, part of the Kardjali region waste center. |
| | Kyrdjali | Project for construction of composting installation (ISPA funding) with planned capacity 11 000 tons – windrow composting of green mass. |
| **SE** | Sliven | Construction of composting installation for biodegradable waste, planned capacity of 50 - 60 000 tons. |

### 2.2.2 COMPLIANCE WITH NORMATIVE DOCUMENTS

The measures envisaged in the present strategy are in compliance with The National Waste Management Program, giving composting a high priority among the recycling measures.

## 3.3 COLLECTION OF PAPER

Establishing a **paper collecting** system is as well important, since with increasing welfare the paper fraction easily reaches 50 - 60 kg/cap./year. Following Bulgarian analysis it is now at about 40 - 45 kg/cap./year in the city regions. In the rural areas the amount is much lower with 10 kg/cap./year, since the consumption is lower and burning plays a role apart from informal recycling (which is more or less part of almost all dwelling structures).

Paper collection is much easier to handle than the collection of bio-waste, since it is dry and non-odorous, rather easy to store in the households, and finally it does not need much handling before given to the paper mill for reuse.

Paper can be collected by Bring-System or by Kerbside system. Bring systems with depot containers are cheaper with a lower efficiency. Experience with different concentrations of installed depots showed that 1.000 inhabitants should be related to one container to achieve 20 kg/cap./year of paper while the amount is only half as high if 2.000 people use one depot.

Kerbside systems provide an own paper bin per house, therefore being more comfortable and effective, thus recovering 80 % of the total paper. This makes primarily sense in multi-family houses and institutional buildings, where the production rate of paper is high. The collected mass can be estimated at 30 – 35 kg/cap./year.



**Figure 5** *Paper Collection*

### 3.3.1 SPECIFIC FRAME CONDITIONS IN BULGARIA

According to the Program for the Implementation of Directive 94/62/EC on packaging and packaging waste, the production of paper and cardboard packaging in Bulgaria for the period 1998 – 2001 varies in the range of 157 thousand tons per 1998 and 119 thousand tons per 2001. To this quantity should be added the quantities of imported paper and cardboard packaging, which for the years 2000 and 2001 are approximately 14 thousand tons. Generally the overall quantity of the packaging for consumption in the country is increasing at 9 – 10 thousand tons per year.

The total quantity of collected and treated paper and cardboard packaging waste generated in the same period varies in the range of 80 thousand tons in 1998 (10 kg/cap/year) and 65 thousand tons in 2001 (8 kg/cap/year)- temporarily decreasing by market and price conditions. These values do not include the quantity of the imported treated waste since these quantities are relatively small as compared to the total recovery capacity for paper and cardboard waste in Bulgaria, which is assessed to approximately 200 000 tons.

Information on existing recycling capacities for paper and cardboard waste, along with the respective capacities is presented in **Table 3**.

The major waste paper recyclers - “Trakia Papir” JCS (for waste from corrugated cardboards) and “Belovo” JSC (for waste of mixed types of papers) - process approximately 90 % of the respective waste at present in the country.

The existing collection systems are limited to buying back separately collected paper and cardboard waste (PCW) from the population or from different industry branches. The system is organized independently from the municipal systems for collection of municipal solid waste using collection centers, collection at the place of waste generation (when big quantities are generated) and implementation of periodic campaigns.

| № | Enterprise | Approximate capacity of waste recycled [thousand tons] |
|---|---|---|
| 1 | Trakia Papir JSC, Pazardzik | 50 |
| 2 | Belovo JSC, Belovo | 30 |
| 3 | Kostenetz HHI JCS, Kostenetz | 12 |
| 4 | Celchart-JSC, Stamboliyski city | 10 |
| 5 | ZKMO – Kocherinovo[1] | 5 |
| 6 | ZMK “Nikopol”JSC, Nikopol | 70 |
| 7 | Pirin Hart JSC, Razlog | 30 |
| 8 | Rulon Iskar JCS, Sofia | 22 |
| 9 | Knaug Gypsofaser | 10 |
| ***10*** | ***Total*** | ***239*** |

**Table 3**: *Capacities for recycling of paper and cardboard waste*

[1] The capacity on pressed boards is not included – it is 18 million pieces per year.

Most of the companies collecting waste through collection centers do have the necessary equipment and capacity for treatment at the place of waste generation. The collection centers serve the population living in the region (households) and the voluntary collectors of PCW. The centers provide for separate storage, packing of PWC for pooling into bigger units, facilitate transportation, compacting of the transport vehicle, containers or other types of transport packaging, provide information etc. The companies serving several centers are basically equipped with transport and lifting equipment, sites, warehoused for storage, equipment for treatment and other necessary facilities for weighting and control of waste quantities. The treatment mainly includes sorting, balling lines (that exist in 20 of the big cities) and by balling presses (60 units).

The alternative collection and recycling of paper and cardboard waste exists in form of "informal separate waste collection" performed by scavengers. This system does not only exist in small villages and towns in Bulgaria, but also in big towns and the material is not only collected at the place of its origin, but also at the landfill sites. Scavengers are mainly interested in collecting materials of higher market value, such as metal, paper and cardboard. Very often they collect not only packaging material but also wires, cables, metal scrap, paper and magazines. However, this informal system of separate collection cannot be considered as a reliable and an effective tool for separate collection.

As a result of the implementation of Directive 94/62/EC on packaging and packaging waste (Bulgarian "Regulation on packaging and packaging waste") 6 recovery organizations were founded. Five of them have permissions to organize separate collection systems for packaging waste. Some of them have already started the projects and programs for separate waste collection:

- "Ecopack Bulgaria"JSC. – in the towns of Razgrad, Smolian, Bansko, district "Oborishte", Sofia municipality.
- "Ecobulpack"Jsc – in the district "Sredetz", Sofia municipality.
- "Bulecoapck" Jsc – in the district "Liulin", Sofia municipality.
- "Recopack" Jsc – in the towns of Tcherven briag, Lukovit, district "Ovcha kupel", Sofia municipality.

Some of the municipalities (Karlovo, Trojan, Kjustendil, Balchik, Bjala) also started their own projects for separate collection of packaging waste – plastics, glass and paper and cardboard, by EMEPA financing. Other municipalities like Rousse, Dobrich and Varna have approved projects for separate collection of packaging materials plastics, glass and paper & cardboard. The projects in Rousse and Dobrich will start by the end of this year.

**Higher potential for paper and cardboard collection exist in the inner cities.** In this respect the National Waste Management Program proposes separate collection of packaging waste in big cities: *"all cities with inhabitants above 7 000 to be included in systems with separate collection".* It means that in the future 5 - 7 years period, higher priority will be given to the big towns to be included in separate collection of packaging materials, particularly for paper and cardboard waste.

Although the increase of quantities of collected and recycled paper waste could be expected as a result of expansion of the economic activities of other quoted waste recycling facilities, the available recycling capacities at national level could be assessed as sufficient ones.

In spite of this, certain risk factors should also be taken into consideration because they would influence the quantities of separately collected and recycled waste. These are mainly:

- The decrease of the price for PCW, paid by the recyclers to the population could cause discontinuation of the collection process;
- The requirements for achievement of production of papers and cardboard of higher quality could result in significant reduction in waste input for production of 1 ton of tradable product. It should be taken into consideration that the waste input is at higher level currently, but with lower quality.

### 3.3.2 COMPLIANCE WITH NORMATIVE DOCUMENTS

The measures envisaged in the present strategy are in compliance with The National Waste Management Program, the Program for Implementation of Directive 94/62/EC on packaging and packaging waste, and the Regulation on packaging and packaging waste.

## 3.4 STABILIZATION OF HOME COMPOSTING

Experience has shown that the amount of about 30 kg/cap./year of organics discovered in the remaining waste from "untouched" **rural** areas is more or less the same as in suburbs after a bio-waste collection had been installed.

The main task in rural areas is therefore not a reduction of organics - since maintaining the actual status would already be a success. However, experience shows that organics increase even in rural areas with a developing welfare. A motivation campaign in rural areas should help to maintain backyard composting and animal feeding. It is the present task to keep the organic amount roughly at the same level until 2010.

The recent contribution of home composting to the reduction of organics is presented in an example:

We found out that the "production rate" of garden waste is at 1 – 1.5 kg/m²/year, thus the primary production of a garden with 800 m² is roughly 800 kg/year, meaning 200 kg/cap./year with 4 persons living in the household. We can roughly add another 60 kg of kitchen waste, meaning 260 kg/cap./year primary productions of organics. Nonetheless, recently only 10 % of this amount appears in the household waste, meaning that **home composting**[2] **shows a reduction rate of 90 %**. This is more than we can ever expect from any separate collection system, and this reduction is just produced by **traditional behaviour of the rural population**.

Measures to stabilize this behaviour are:

- Information campaigns;
- Support by providing home and on-farm composting systems;
- Support by a flexible fee system (as a future option).

The **information campaigns** should primarily increase the awareness of the population, that recycling is not only of direct benefit for the households by avoiding cost for fertilizers and humus soil (that is what the people already know), but as well that any avoided kilogram of organics in the waste is of tremendous importance to keep ground and surface water clean. The general knowledge on effects of waste components on nature and

[2] "Home composting" here is a synonym for a not precisely definable "treatment-mix" of real composting, animal feeding and – in smaller scale - burning of wood and paper in the stoves

environment are based on the believe, that organics do not show any negative effects, since they are “natural” and biodegradable (while “artificial” products like plastics and glass are often considered to be more dangerous in landfills). Information must also be provided on the negative effect of organics in landfills (leachate, mobilisation of heavy metals by organic acids, production of methane etc.) in an understandable way, showing that home composting or animal feeding is not only of direct advantage, but that all owners of gardens and animals have an own responsibility to hold their organic waste away from landfills.

**Support by providing home composting systems** is primarily estimated as a gesture by municipality for the **high appreciation of home composting**. In research projects in rural and suburb areas of Germany (around Munich, 1990) we found, that especially “urban” people, who settled outside the inner cities in an own house, started home composting because they got a free composting bin, but their share on the whole population was between 5 - 10 % . Nonetheless 15 - 25 % of the household took a “free” compost bin, and they said that they increased composting.

### 3.4.1 SPECIFIC FRAME CONDITIONS IN BULGARIA

The pilot projects in Bulgaria with free compost bins showed another reaction, especially a much lower demand for free composters – in the range of 2 to 3 % of the population**.** This is due to the fact that the **quality of own organic kitchen waste reuse is higher than in Germany: not composting, but feeding animals**.

In the rural areas, the general practices concerning the handling of bio-waste are:

- using kitchen and garden leftovers to feed animals;
- burying vegetable and kitchen waste in the soil (backyard or in the garden without consequent use);
- heaping up mixed piles with manure, vegetable and kitchen waste in the field (the heaps are not turned afterwards, but in two or three years the (already composted) material is used as a soil improver);
- heaping up piles only with manure (the heaps are not turned afterwards, but in two or three years the composted manure is used as a soil improver);
- burning garden waste and leaves.

At present several pilot projects for home composting are running in the country. The projects embrace about 2000 families in total, which have been provided with home composters.

Home composting is one of the preferred measures specified by small municipalities with respect to biodegradable waste treatment as part of Municipal Waste Management Programs.

The summary table for planned/running home composting projects in Bulgaria is provided on the next page. **In general, the technical advantage of a new composting bin is of less importance compared with the general motivation of the population, recognizing that what they traditionally do is of environmental importance and appreciated by the municipality.**

### 3.4.2 COMPLIANCE WITH NORMATIVE DOCUMENTS

Following this experience the National Waste management Plan estimates the number of free composters by the end of 2007 at around 19 500 which is about 2 % of the total rural + suburb population (4 people per composter).

Any provisions for on-farm composting sites have to be in compliance with Regulation 7 on the Requirements, which must be met by the Waste Treatment Facility Sites, Regulation 8 on the Conditions and Requirements towards the Construction and Operation of Waste Landfills and other Facilities and Installations for Waste recovery of the Ministry of Environment and Water, and Disposal and from 1.04.2006 with Regulation 50 for veterinarian requirements to animal by products not intended for human consumption of the Ministry of Agriculture and Forestry.

**Figure 6** *Backyard or garden composting*

**Table 4** *Projects for supporting home composting*

| Region | Municipality | Planned measures/home composting projects |
|---|---|---|
| **NW** | Mezdra | Pilot project for home composting (2004 - 2007), covering approximately 0.5% of the households. Encouraging home composting to cover up cover 30 % of the households in the villages and 10 % of the one-family houses in the city regions to 2010 and 50 %/15 % in 2015. |
| | Dimovo | Family composting of biodegradable waste. |
| | Berkovitza | Current project for home composting, 200 composters. |
| **NC** | Belene | Implementation of family composting system. |
| | Polski Trambej | Project for family composting for 180 families from 4 settlements. Project value 50 000 leva. Volume of composting containers - 400 l/600 l. |
| | Yablanitza | Introducing of home composting. |
| | Apriltzi | Current project for home composting, 200 composters. |
| | Vetovo | Finalized project for home composting, 240 composters |
| **NE** | Zavet | Introducing of home composting. |
| | Smyadovo | Introducing of home-composting. |
| | Hisarya | Project for buying of home composters, sent to EMPEA for financing. |
| | Hitrino | Separate collection, of household waste and home composting |

| Region | Municipality | Planned measures/home composting projects |
|---|---|---|
| | Venetz | Project "Minimization of boidegradable household waste via introducing of home composting in plastic bio-waste bins". |
| | Beloslav | Project for „Family composting of plant and animal waste inplastic bio-bins". |
| | Veliki Preslav | Current project for home composting, started in 2004, 265 composters, different volumes. |
| **SW** | Pernik | Home composting project for Studena villagers. |
| | Razlog | Project for home composting, presented to EMPEA for financing. |
| | Novi Iskar | Finalized project for home composting, 250 composters. |
| | Petrich | Project for home composting, presented to EMPEA for financing. |
| | Blagoevgrad | Home composting and separate collection. |
| | Gorna Malina | Home composting projec for Studena villagers. |
| **SC** | Topolovgrad | Project for family composting started in 2005, introduced in 250 households. |
| | Bratzigovo | Buying of home composters for plant waste. |
| | Velingrad | Finalized project for home composting started in 2001, 124 families are involved, supplied by bio-composters with volume of 300 and 750 l. |
| | Smolyan | Current project for family composting started in 2004, 200 composters, volume 350 l. |
| | Lesichovo | Introducing of home composting. |
| **Region** | **Municipality** | **Planned measures/home composting projects** |
| | Kardjali | Current project for home composting, 250 composters. |
| **SE** | Pomorie | Introducing of home composting system. |
| | Ruen | Building of a system for home composting 300-750 l composters. |
| | Malko Tarnovo | Project for home composting will be introduced in 20 households. |

## 3.5 BIOWASTE COLLECTION

For several decades during the last century - and in many countries even up to now - mixed household waste has been composted, using technical means to separate the organic fraction from other waste components. Despite the technical progress in refining the produced compost it was not possible to remove contaminations completely. Thus the concentrations of heavy metals remained too high, threatening the soil quality by application of this kind of compost. Separate collection of food waste and green organics (bio waste) by the producer was recognized to be the only way to produce "clean" compost (as a product of backyard composting, using the same separated materials).

Following this basic intention, organic wastes are collected separately by the citizens apart from the mixed remaining waste. Sound and proper collection is assumed with contamination lower than 5 %. Paper and cardboard can principally be added to the organic waste fraction without endangering the compost quality, if esp. the printing colours are almost free of heavy metals. Of course, the specific quality of the paper fibre is lost by this way of recycling, so the collection of paper as a separate, own fraction is generally the better option.

Since the mid-nineties the separate collection and utilization of bio waste forms part of waste management practice in almost all - even large - German, Austrian, Swiss, Dutch and meanwhile also approx. 40 % of Italian municipalities.

Separate collection of bio waste (and also paper products) has and will contribute significantly in reaching the set targets.

In terms of amounts and quality of bio waste collection, there are differences when looking at the three main types of dwelling structures:

A) **Suburbs** – Detached dwellings (mainly with garden)

B) **Inner city** - Multi-unit dwellings (mainly without garden)

C) **Rural areas** – Small villages and single houses

As outlined in chapter 3.4, each person roughly produces 70 kg/year of organic kitchen wastes (remainders of vegetables and fruits, coffee, wet papers, etc). In areas with attached garden, an amount of 1 kg/m²/year must be added.

The characteristics of the mentioned dwelling structures can be schemed as following:

**Structure A) – Suburbs, single family houses:**

High specific organic amounts, individual bins per household, small fluctuation, different degree of education, better community control.

People in single family households taking care of an own garden have a higher awareness of nature, soil, plants, compost and nutrients, making them more accessible for the idea of bio waste collection and the production of compost. A relevant share of garden waste is already self-composted, but due to other traditions backyard composting in suburbs does not reach the efficiency of rural areas – at least half of the primarily produced organics are found in the household waste, meaning 100 - 120 kg/cap./year. Bio-waste collection can reduce this amount to 30 - 40 kg/cap./year. By practical experience it must be considered, that bio-waste collection reduces backyard composting activities, in such a way that roughly each kilogram of reduced organic in the mixed waste is accompanied by almost another kilogram of former self-composted organic waste. 100 kg collected bio-waste thereby correspond to 70 kg reduction of organics in the mixed waste.

**Structure B) – Inner city, multi-family houses:**

Low specific organic amounts, non-individual bins per household, higher fluctuation, different degree of education, lack of efficient community control.

The higher the number of families living in a house and using centralized bins for separation, the lower – in tendency – is the quality of the separated recyclables - bio waste within them.

Another option for bio-waste collection in the inner part of the city is from areas with high concentration of restaurants, canteens, food shops, etc. This can be organised by providing the restaurants and food shops with bio-waste containers for separate collection of food waste.

As experiences in bio waste collection e.g. in the inner city of Berlin show (similar to the collection of bio waste in other inner city's), the recovery rate of organics in bio waste is roughly 30 %, meaning 20 kg/cap./year. This results from about 30 % of the inhabitants, who collect almost 100 % of their organics with high purity, while 70 % do not participate. One specific aim of the bio waste collection in these areas is to prevent the non-participants from throwing their household waste into the bio waste bins. The differences in the specific amount of collected bio-waste in different German cities as shown in figure 7, are mainly due to varying percentage of suburb households.

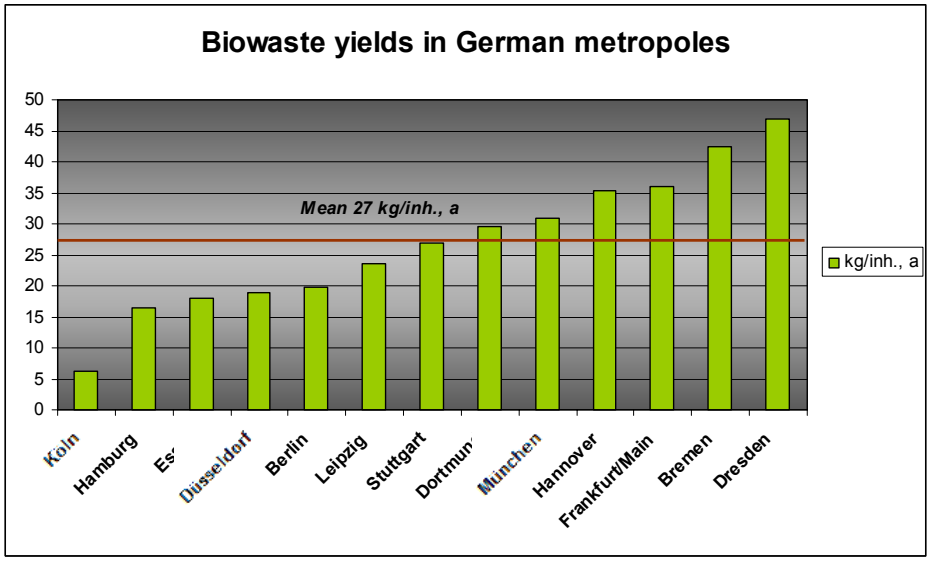



**Figure 7** *Yields of bio waste (collected in wheel bins = "green bin", "bio waste bin") in various German cities (>500.000 population)*


**Figure 8** *Bio-waste collection*

**Structure C) – Rural areas**

As already mentioned in chapter 3.4, the amount of organics in the waste is already very low due to highly efficient traditional self-composting in rural areas. Installation of bio-waste collection would just recover self-composted material without or just a very small

reduction effect on the organics in household waste. As long as backyard composting can be kept at the same level as now, there is no need to install a separate collection of organics.

### 3.5.1 METHODS TO ACHIEVE A HIGH BIOWASTE QUALITY

Besides the aim to achieve a high reduction rate for organics by bio-waste collection, the quality of the bio-waste must be stabilized at a high level.

In the below figure, the impacts on bio waste quality are outlined, showing which of them are important in inner city (yellow) and suburb areas (light green).

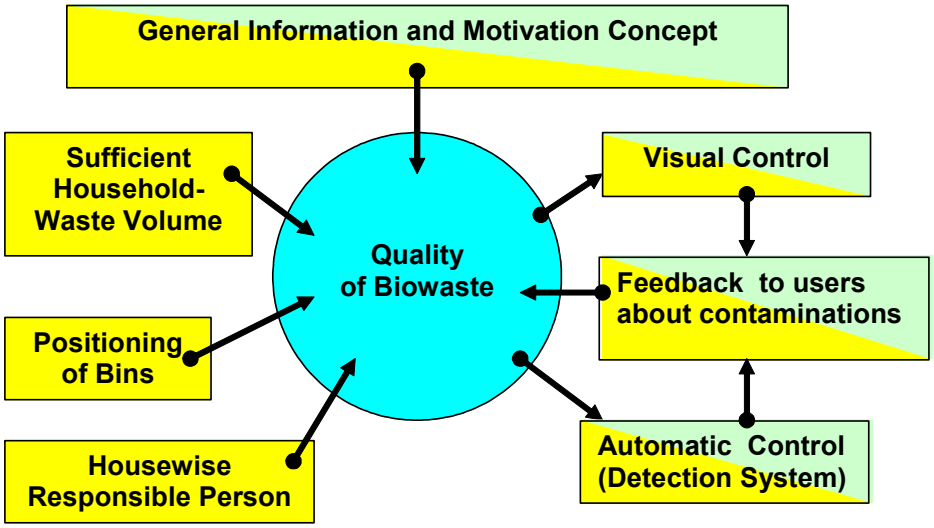



**Figure 9** *Elements of a general information concept to improve the quality of bio waste*

These impacts are briefly described below. They can be divided in

- *General information* about sense and necessity of bio waste collection
- *Logistic impacts* on bio waste quality
- *Control systems* and *quality feedback* to users

***The next chapters – related to bio-waste collection – are as well to be read in relation to all other methods of separate collection or avoiding of waste components like paper collection and supporting of backyard composting.***

**General information concept**

The information concept must make use of all available media and communication strategies to reach the population, including

- Individual handouts/flyers for each household, describing
  - the need for separate collection
  - the mass relevance of organics (30 - 40 % of household waste)
  - a detailed list of organic materials to be collected
  - a detailed list of wastes not to be thrown into bio waste
  - a method to collect (wrapping waste into paper, bins to be used etc.)
  - the internet information source / contact telephone at the municipality.
- Repeated reports on TV, radio, newspaper
- Teaching materials and activities at schools (children educate their parents)
- Mobile information van on markets and other public events
- A personal visit of each household is recommended, to prove the vital interest of the community in the concept
- Distribution of small plastic bins to collect organics in the kitchen

For both, in single family areas and in the inner cities, the personal contact at the introduction of the separate collection is highly recommended. The personal visits to the households are to be listed carefully and repeated (until 90 % of the households have been reached!).

Prior to the personal visit,

- the information staff must be carefully educated, not only in terms of bio waste collection, but also with respect to any other questions that might occur at the house door talk, meaning the treatment of bio waste, other recyclables, resulting costs etc.
- the date/period of the information visit must be announced precisely in a written form to each household, making people aware that someone is appealing at them.
- the budget for a start-up campaign covering these issues is to be estimated at 4 - 7 € per person in the collecting area.

**Sufficient volume of household waste**

In case, the waste fee depends on the size of waste bin (if flexible waste fee system is introduced) it is possible that households esp. in the inner cities will be tempted to choose smaller bins (due to money savings). As a consequence, some people may throw the waste in the free volume of the bio waste bin. If contaminations of bio waste are observed, the filling status of the regular waste bins must be checked and its number / volume consequently corrected. The volume to be provided depends on the other collection options for recyclables and bulky wastes, roughly it should not undergo 30 l/cap./week.

In single family structures this parameter needs not to be controlled with the same accuracy as in inner cities, since

- this situation does not occur so often

- most of the users have an established respect of the bio waste bin
- responsibilities for contamination of bio waste can be re-individualized easily.

**Positioning of bio waste bins**

In inner city's collection areas, the bio waste bin must not be the first accessible bin in the group of waste bins, but should be placed at the last, most distanced position. Lazy people tend to throw mixed waste in the next bin within reach, whatever it is meant for. Experiences in different cities reveal that re-positioning of the containers in the way "Mixed waste upfront, recyclables rear, bio waste last" showed a substantial quality increase of the bio waste.


**Figure 10** *Positioning of bins and recyclables behind the containers for mixed waste*

**Control Systems**

It is the aim of the control systems to identify impurities in single waste bins. If contamination is identified, information is given to the user(s) to do better. If contamination continues, a more severe warning is given, until finally the bio waste collection is ceased with higher costs for the inhabitants.

Before deciding for a specific control system, the entire method of feedback and reaction must be cleared.

Two basic control systems are in operation:

**Visual control:**

Before discharging the bio waste bin, the loader looks inside and checks the quality.

*Advantage:* No additional costs for technical detection systems

*Disadvantage:* Only obvious contaminations can be identified. Normal waste, covered by a layer of organics, will pass this check without complaints.

**Automated control:**

The bin lifting & discharging system at the truck is equipped with a control unit which by the eddy current principle detects metals (as components of household waste) in the bio waste bin.

*Advantage:* Hidden objects (containing metals) will be detected as well.

*Disadvantage:* Additional cost, only metal is detected.

### 3.5.2 TREATMENT OF BIO-WASTE

This organic waste fraction can be treated by digestion or composting, whereas digestion is more recommended for wet material from inner city collection and residues e.g. from the food industry. The production of biogas recovers the energy in the material. Composting is the cheaper method esp. for smaller treatment units in the range of 5 000 – 20 000 tons/year and requires more structured material for a good aeration.

The most important task for treatment of bio-waste is the avoidance, respective elimination of odour emissions, since this is the major source of complaints in the surroundings. For this reason, composting facilities of more than about 20 000 Mg/a for bio-waste should be covered, capturing and deodorizing the air by bio-filter.

**Conclusion: Bio-waste collection** is the favourite option for suburbs with garden areas, since they provide bigger amounts of organics in the waste at a reduced trend for backyard composting. To collect bio-waste in inner cities is a less effective effort, the participation rate is rather low (30 %), since kitchen waste is the most inconvenient material to be collected separately. Efforts have to be put to establish such collection first in areas with high concentration of restaurant and food shops (commercial organics). In rural areas this kind of separate collection is not yet recommended, since it decreases the motivation for backyard composting. In rural areas as well as in suburbs, this trend should be supported by a sound **waste fee system,** making it possible for the inhabitants to save money by using smaller bins or longer discharge intervals, respectively.

### 3.5.3 COMPLIANCE WITH NORMATIVE REGULATION

The measures envisaged in the present strategy are in compliance with The National Waste Management Program, which envisages the installation of 18 regional composting plants. Requirements of biological treatment facilities are described in the *"Regulation 8* the Conditions and Requirements towards the Construction and Operation of Waste Landfills and other Facilities and Installations for Waste recovery *",* Article 45 – 54, regulating especially material control, process monitoring and measures to reduce negative environmental impacts from these facilities.

**Table 5** *Characteristics of composting and anaerobic fermentation*

| Parameter | Composting | Digestion |
|---|---|---|
| Proliferation of micro organisms | F a s t (aerobic organisms) | S l o w (anaerobic methane bacteria) |
| Input material | stabile structured, humidity < 65 %, = “solid" | Low structured Humidity > 65 % = "slurry" |
| Products | $CO_2$, $H_2O$, compost | CH4, CO2, Fermentation residue, trans-formed to compost |
| Produced Energie | H e a t (evaporated Water ) | B i o g a s (70 % $CH_4$, 30 % $CO_2$) Heating value 7 kWh/$m^3$ |
| Degradation time | 7-10 weeks | 1 - 3 weeks (plus 2 - 4 weeks maturation |
| Sensitivity to milieu (temperature, pH) | low | high (esp. Methan organisms) |
| Energy (el.) Input/Output/Sum | - 40/0/-40 kWh/Mg | - 60/210/150 kWh/Mg |
| Leachate/Waste Water | -50 - 50 l/Mg | 300 - 400 l/Mg from dewatering of fermentation residue |
| Area Demand | 0,5 - 1 $m^2$/Mg,a | 0,2 - 0,7 $m^2$/Mg,a |
| Treatment costs | 35 - 70 €/Mg | 50 - 80 €/Mg |

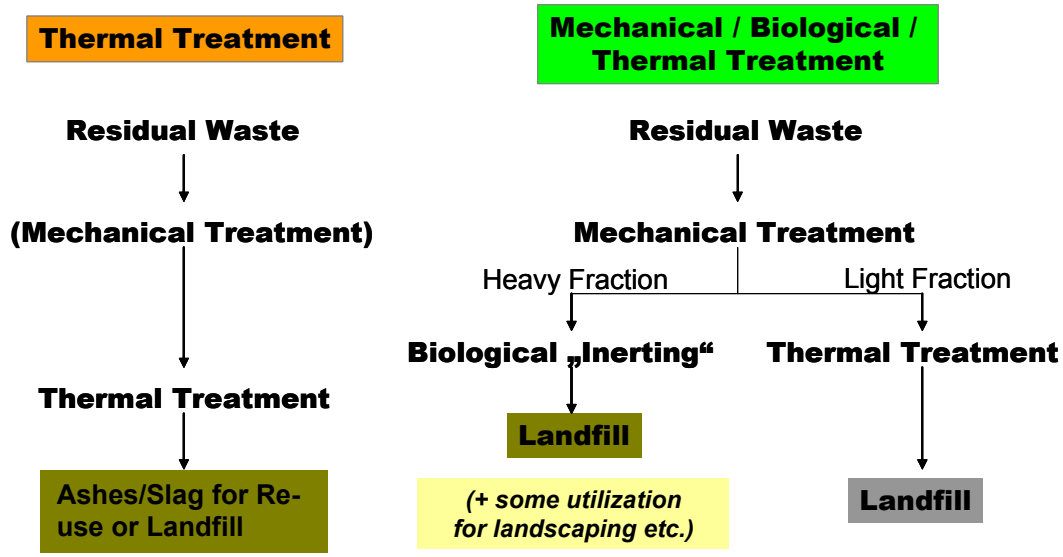
**Figure 11** *Indoor composting system*

**Figure 12** *Digestion plant for bio-waste*

## 3.6 TREATMENT OF BIODEGRADABLE FRACTION IN MIXED WASTE

Although waste minimisation and waste recovery are very important steps in meeting the requirements (see above), capacities for reducing the content of biodegradable parts of residual MSW have to be built. The reduction of the quantity of biodegradable parts of residual MSW going to landfill can be achieved by two major technologies which are

- Incineration / thermal treatment
- Biological degradation in MBT (mechanical-biological-thermal treatment)




**Incineration with energy recovery of at least the high calorific parts of MSW forms in the long-term an integral part of both treatment (stabilisation) technologies.**

**Figure 13** *Basic Technical Alternatives for treatment of residual MSW prior to landfill*

## 3.7 THERMAL TREATMENT

The thermal treatment will be performed 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 and completely oxidized. The non burnable fractions are removed as slag from the bottom. The heat generated will be utilised in the vessel for steam and electricity production. 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 via the chimney to the ambient air.

Solid residues are slag and ash. Slag is a material which can usually be deposited 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.

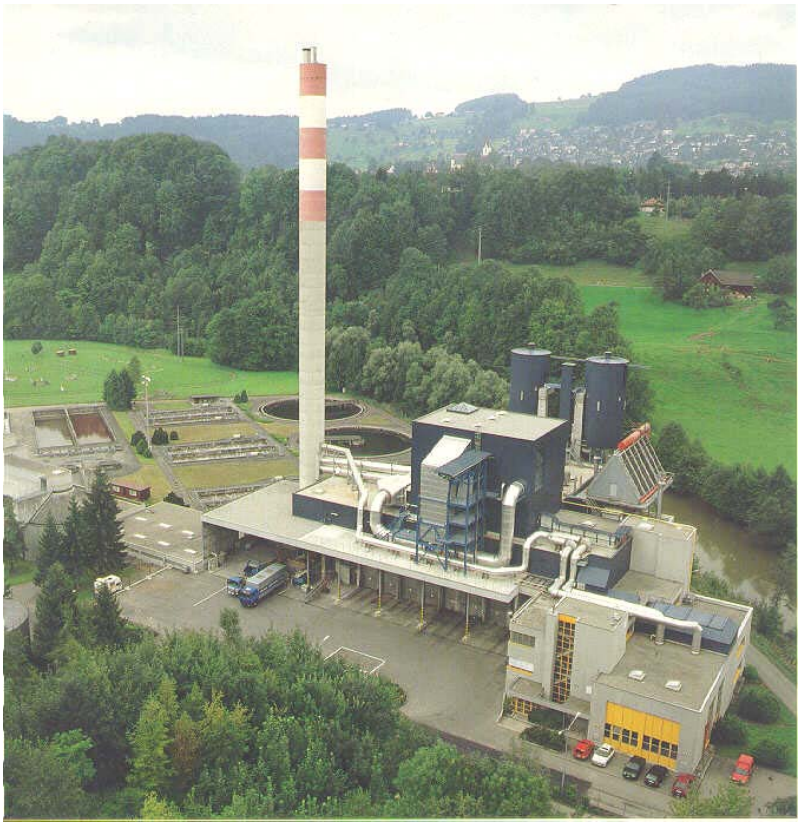


**Figure 14** *Incineration plant*

Because of their high content of moisture, native organics are more or less regarded ballast material for the combustion, lowering the heating value. By the nature of combustion, bio-degradable fractions are completely destroyed, their ashes leaving no further effects on the environment. Because of this and due to very stringent emission reduction standards, incineration is to be regarded a very clean disposal system for waste, including organic waste – but also as the most expensive. Other thermal treatment systems like pyrolysis go into the same direction.

### 3.7.1 SPECIFIC FRAME CONDITIONS IN BULGARIA

As discussed before the incineration of waste is not a widespread practice in the country. Currently there are no installations for incineration of municipal waste in Bulgaria.

However from the position of current “waste situation” **in Sofia**, it is most likely that the municipality will go into the direction of building an **incineration plant.**

Main factors at the moment are:

- **The landfill Suhodol has been closed on 02.10.2005** (according to the decision of Sofia Municipality Council and the permit for exploitation.)
- As a temporal solution of Sofia's waste crisis the Municipality bought **three baling facilities**, each with a **capacity of 30 - 50 tones of garbage per hour** (the reported daily amount of waste for Sofia is 1000 tones). The bales will be stored temporarily until the construction of installation for their treatment.
- At the moment a committee from Sofia Municipality has called for tenders for the construction of **waste incinerators or other facility that have the same treatment capacity for waste reduction** in Sofia.

There is no official information available about the planned capacity of the plant and the expected date for putting it in operation.

Assuming that Sofia starts the planning and construction of an incineration plant soon, this facility could be available in the year 2013. Assuming further, the capacity will be at about 350 000 Mg/year, the **elimination capacity for biodegradable waste will be roughly at 150 000 Mg/year.** This is about 25 % of the additional reduction demand all over Bulgaria.

### 3.7.2 COMPLIANCE WITH NORMATIVE REGULATION

Any installation for incineration and co-incineration of waste has to comply with the conditions and requirements specified in Regulation No.6/28.07.2004.

## 3.8 MECHANICAL-BIOLOGICAL TREATMENT

The mechanical-biological treatment (MBT) comes technically close to the mixed waste composting: Fractions such as plastics, paper, cardboard and textiles are first separated by screening or hand-sorting, the enriched organic/inert fraction is send to a biological treatment, either "composting" or digestion. After this treatment, the biological activity is reduced to about 5 % of the input material, and can be deposited on landfill almost without any further negative effects. The advantage of the MBT is the application in smaller units of about 30 000 – 50 000 tons/year, this being the size of a county of about 150 000 inhabitants. This system is quite flexible, leading the coarse waste stream fractions either to material recovery (by hand-sorting) or to energy recovery. The systems need access to a landfill to take 20 – 50 weight-% of the input, depending on the scale to which the coarse fraction can be used.

The idea is to combine the advantages of waste incineration - which lies in the energy recovery - with a biological degradation of those parts of the waste which have a low calorific value, due to high water content or which are inert.

In such a combined approach, three different treatment steps can be performed at different locations. It is possible to perform the mechanical treatment very close to the town where the waste comes from. The biological treatment can take place at a landfill - where the waste will be going to after treatment. The incineration of those waste fractions possessing a high calorific value can take place at another location where a suitable incineration plant is situated. In general application the mechanical-biological treatment is located close to the landfill

This possible combination of different tasks at different locations makes the system flexible to changing waste quantities and waste composition.

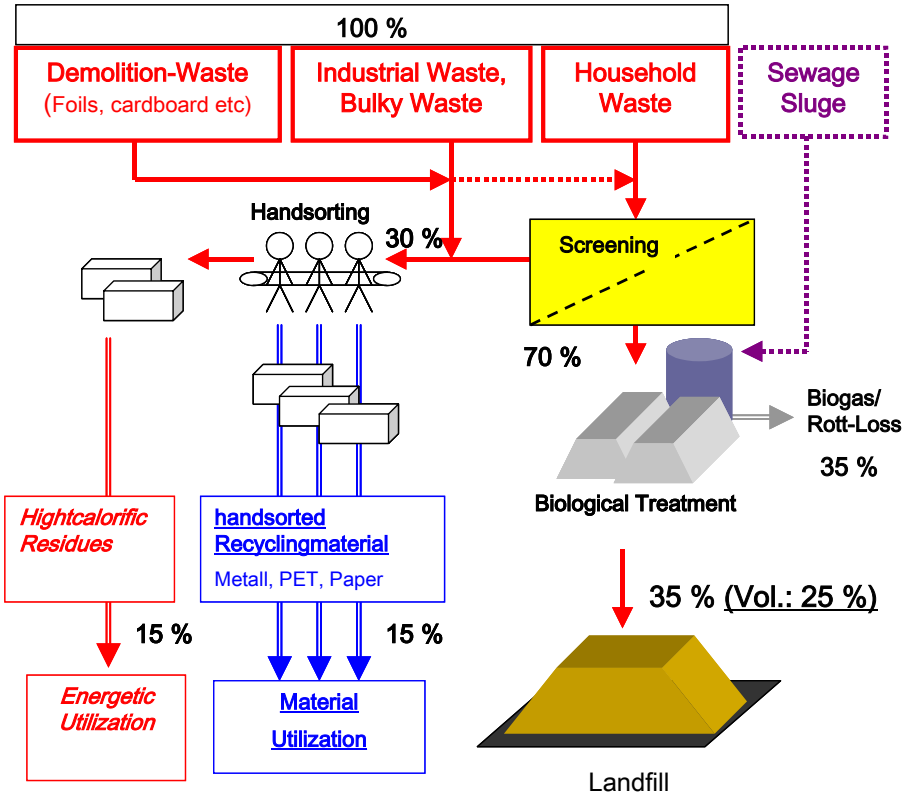



**Figure 14** *Typical process of a mechanical-biological treatment of MSW*

The installation of a MBT does not block the way for bio-waste collection, which is perhaps introduced later. Most of the biological systems for MBT allow a separate treatment of bio-waste (in one line) and the fine material of the MBT (in the other line). Thus, the biological capacity can be used for the different input materials.

### 3.8.1 SPECIFIC FRAME CONDITIONS IN BULGARIA

At present, there are no installations for mechanical-biological treatment of household waste in Bulgaria.

Two municipalities declared their intention for building mechanical-biological treatment facilities in the future: Plovdiv and Rousse. Recently the Municipality of Veliko Tarnovo has shown interest for building installation for separation and treatment of waste which includes composting unit. Currently a tender documentation is under preparation.

**Plovdiv**

At the present the waste in Plovdiv municipality is going to landfill for solid household waste – Plovdiv, located in v. Tzalapitza, 18km west of the town, which has a permit for exploitation until the end of 2006.

The plan exists for the construction of a "Waste Factory" with the **capacity 127 000 t/y** and landfill for non liable waste. The waste facility will serve 630 900 people from 13 municipalities. The project foresees the construction of a separation and composting unit, administrative buildings and a landfill with four cells. The main part of the "factory" is the composting unit.

There is no information about separate collection of biodegradable waste (only that the parks and recreational areas cover about 9300 dka.) as well as on hazardous waste. According to the updated "Waste management program", the separated bio-waste will be used for compost production after the building of the a.m. plant.

**Rousse**

The municipality of Rousse submitted a request for financing to EMEPA (Enterprise for management of the environment protection activities) concerning the financing of a complex project for "Construction of installations for waste composting and separating – Rouse". The total requested amount is 15 414 224 BGN for equipping of the separating installation, technological equipment for the composting installation by "Biodegma" technology, with a **planned capacity of 15 000 t/y** and transport fleet and weighing-bridge.

A project for separate collection of recyclables has been approved by EMEPA at the end of 2004.

### 3.8.2 COMPLIANCE WITH NORMATIVE REGULATION

The measures envisaged in the present strategy are in compliance with The National Waste Management Program, which envisages the installation of 18 regional composting plants for MSW, which also includes MBT-facilities. Requirements for biological treatment facilities are described in the *Regulation 8* the Conditions and Requirements towards the Construction and Operation of Waste Landfills and other Facilities and Installations for Waste recovery*,* Article 45 – 54, regulating especially material control, process monitoring and measures to reduce negative environmental impacts from these facilities.

**Figure 15** *Example of a mechanical-biological treatment plant*

## 3.9 SEWAGE SLUDGE TREATMENT

The expected development of sewage sludge is listed in the table below.

**Table 6**: *Expected development of sewage sludge – dry and wet masses*

| | | year | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | **2000** | **2005** | **2010** | **2015** | **2020** |
| | | | | | | |
| Population | Number | 8.149.468 | 7.716.788 | 7.495.482 | 7302 371 | 7302 371 |
| Population to WWTP | Number | 3.000.000 | 3.200.000 | 3.500.000 | 3.966.000 | 4.362.600 |
| Total Equivalents to WWTP | Equivalents | 5.200.000 | 5.450.000 | 6.500.000 | 7.233.000 | 7.956.300 |
| Specific sewage sludge - wet | wet kg/pers,a | 55 | 55 | 55 | 55 | 55 |
| - dry (assumed 30 % dry mass) | dry kg/pers,a | 16,5 | 16,5 | 16,5 | 16,5 | 16,5 |
| **Amount of sewage sludge** | **wet tons/a** | **286.000** | **299.750** | **357.500** | **397.815** | **437.597** |
| **(assumed 30 % dry)** | **dry tons/a** | **49.500** | **52.800** | **57.750** | **65.439** | **71.983** |

Three options are available to reduce sewage sludge going to landfill:

- agricultural use
- co-treatment in MBT
- incineration (single or in industrial processes)

A survey of these options is provided in **Figure 16**.

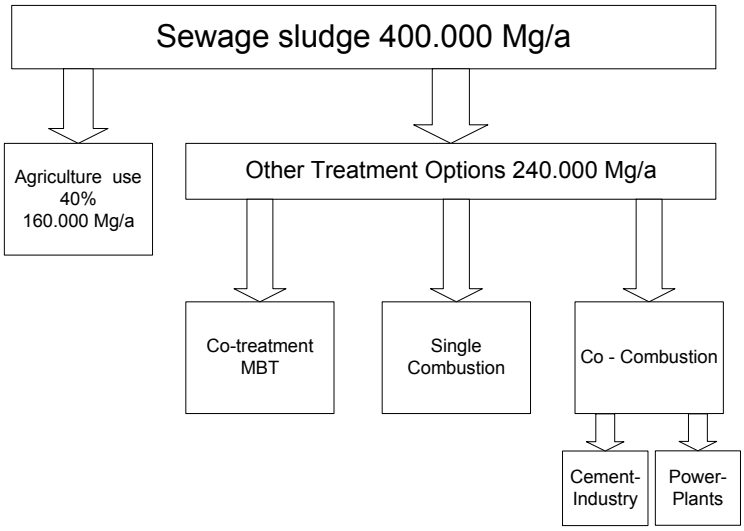



**Figure 16** *Options for reduction of sewage sludge*

### 3.9.1 AGRICULTURAL USE

Based on the already available sludge analyses it has to be stated, that most of the now produced sludge is not fit for use in agriculture. For example, the comparison with MAC shows that sludge from WWTP in Bourgas is suitable for use in agriculture, whereas the level of Cd measured in sludge of the WWTP in Sofia is above MAC. The major reasons for this lies the fact that esp. the bigger WWTPs treat also discharges from industrial sources. In general, better sludge quality is achieved in smaller WWTPs, treating only waste water from pure housing structures. Assuming a better control and pre-cleaning of the few commercial and industrial discharges and a sufficient treatment of the sludge for stabilization and hygienic standards[3] it can be estimated, that **about 40 % of the total sludge masses and can be used in agriculture.**

### 3.9.2 SINGLE COMBUSTION OF SEWAGE SLUDGE

The heating value of dewatered sewage sludge is very low, making it impossible to burn it in one single step in a continuous process. Therefore, one method is to add auxiliary fuel – see in **Figure 17**.

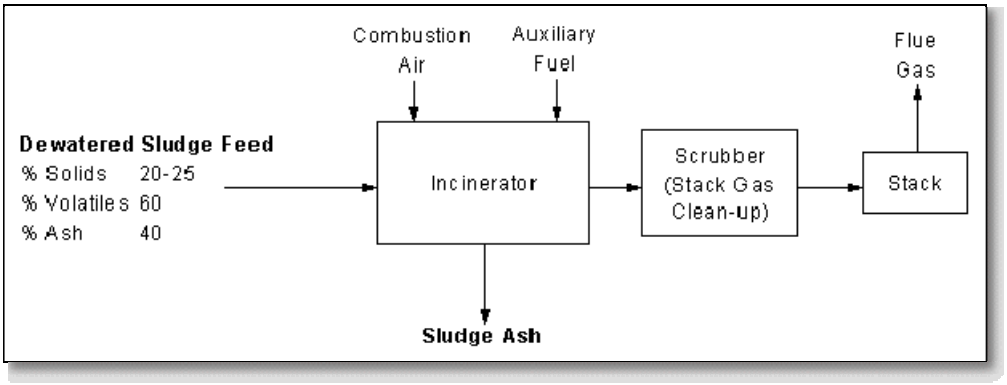



**Figure 17** *Sewage sludge incineration with auxiliary fuel*

The other way is to separate the treatment process in two steps: Drying of the sludge to obtain remaining moisture below 20 %, using the hot flue gas of the combustion unit for this task. This dried material is then transported to the combustion unit. The general system is shown in **Figure 18**.

The system is developed by different providers using several options by combining the two thermodynamic steps – direct and indirect heat transfer for drying, pyrolitic effects, gas guiding etc.

[3] According to the regulation for the established order and methods for utilization of sludge originating from wastewater treatment plants sludge must be treated, before being used in agriculture. Experts judge that 60 – 70 % of the sludge in Bulgaria is not treated. Recently, only the bigger WWTPs (e.g. in Sofia, Plovdiv, Bourgas, Varna and Plovdiv) treat their sludge.

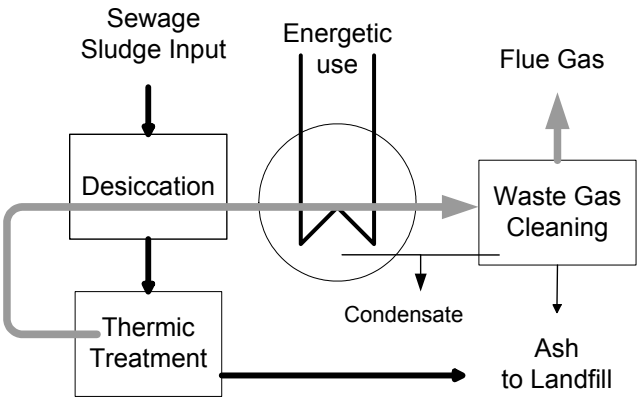



**Figure 18** *Sewage sludge incineration with separated drying and combustion*

### 3.9.3 CO-COMBUSTION OF SEWAGE SLUDGE IN INDUSTRIAL PROCESSES

The most important industrial processes to treat sewage sludge are co-combustion in **coal power plants** and **cement kilns**. In both cases, coming from the original process, sewage sludge is not a *desired* material with a substituting potential for regular fuel, since the moisture is too high, the heating value too low. The only process technical advantage is the homogeneity of the dewatered sewage sludge, making it possible to co-treat it with the other raw materials and fuels. Being added only in small shares of the input, the regular process provides a sufficient tolerance to evaporate the moisture of the sludge and burn it finally.

There is no substantial problem in feeding, conveying and combustion itself in most of these facilities, but all industrial processes co-combusting sludge must fulfil the strict EU-Directive 2000/76/EEC which intends that co-combusting does not cause higher specific emissions than a specialised single combustion. This is the crucial point and the main obstacle, if these industrial processes are not yet fully equipped with the concerned purification units for the flue gas.

**Figure 19** shows the principal way to mix sewage sludge with coal in a power plant, using the coal grinding system as a homogenising aggregate for both coal and sludge.

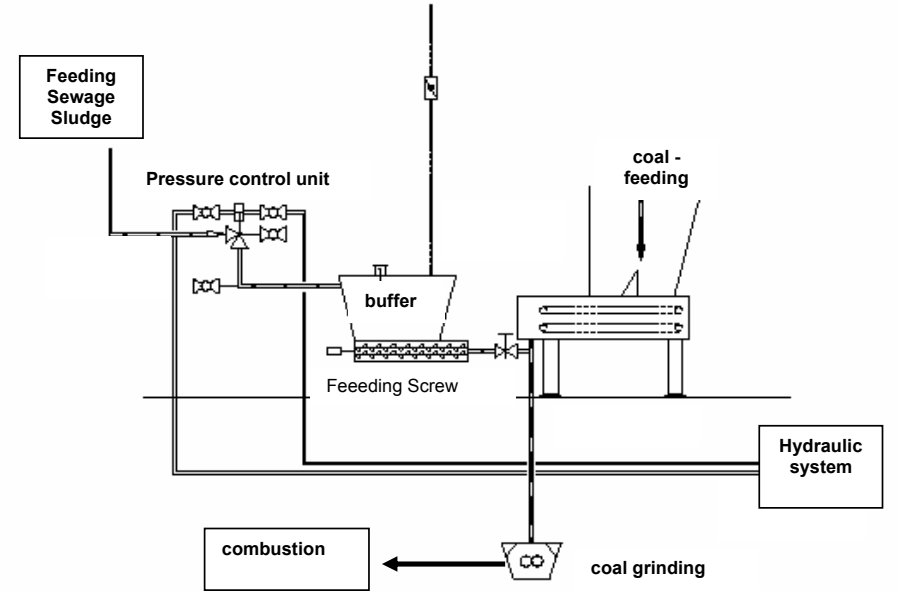



**Figure 19** *Sewage sludge feeding system in coal power plants for co-combustion*

### 3.9.4 SPECIFIC FRAME CONDITIONS IN BULGARIA

As a result of the conditions described in the Interim report it was estimated, that only a part of the sludge produced (about 40 %) can be used in agriculture, provided that the sludge is treated.

Therefore, other options of separate treatment of contaminated sewage sludge should be investigated and assessed.

One possibility is to burn the sludge in the **coal power plants**, during the production processes. However, the major part of them are old installations, owned by the government, presently facing many difficulties regarding the implementation of the new environmental legislation, mainly due to the quantity and quality of flue gas emissions.

As burning the waste (particularly sewage sludge), must be performed in accordance with the requirements of the Directive 2000/76/EEC for Incineration of Waste (introduced by Bulgarian Regulation No.6/28.07.2004 for the conditions and requirements for the installations for incineration and co-incineration of waste), which puts some restrictions, especially on air emission monitoring, at this moment none of the coal power plants in Bulgaria has declared an intention to burn waste or sludge.

The second possibility is co-incineration in the **cement industry,** which manifests interest for examination of the possibilities for reconstruction and equipment of the existing installations in order to incinerate different types of waste as additional fuel during the production processes.

Four of the five cement factories in Bulgaria, declared their intention for using different type of wastes (with high calorific value) as alternative energy source in cement produc-

tion with the submission of their applications for integrated permit to the Executive Environmental Agency (EEA). Their main intention is to co-incinerate high calorific value waste, such as crude oil processing waste, waste oil, tyres and other. Contaminated sewage sludge can also be co-incinerated in these plants, provided that is suitably dried.

**Table 7** *Characteristics of cement facilities*

| Region | Cement plant | Brief activity description | Projected capacity | Actual capacity |
|---|---|---|---|---|
| **NW** | **Holcim Bulgarai AD** (Beloizvorski cement) Beli izvor, Vratza | Cement production by dry method. | Raw – 4300 t/day | 2.000t/day |
| | | | Clinker-2300 t/day | 1.340 t/day |
| | | | Cement –1200 t/day | 780 t/day |
| **SC** | **Vulkan AD**, Itacementi Group Dimitrovgrad | Production of cement and clinker | Clinker - 712 t/day | 554 t/day |
| | | | Cement -750 t/day | 516 t/day |
| | | pyrite coals | Not in operation | Totally - 10 t/y |
| | | lead slags | 7 t/y | |
| | | payalit? | 8 t/y | |
| **NE** | **Devnya cement AD** Italcementi Group Devnya | Production of cement clinker, marble stone | Cement | 100% load during 2001 |
| | | | Clinker - 243 t/h | |
| | | | Marble stone - 120 t/h | |
| **NW** | **Zlatna Panega cement AD** TITAN Cement | Production of clinker and cement | Clinker - 800 000 t/y | 319.687 t/y clinker |
| | | | Cement | 405.750 t/ycement |

# 4 IMPLEMENTATION CONCEPT

Establishing the mentioned "soft" measures to reduce biodegradable waste will show positive results, but due to a major portion of the population living in the "inner city" with small or no options to reduce organics by bio-waste collection, the reduction tasks after 2010 can only be achieved by treating the remaining mixed waste – either by incineration **or by MBT**. Since incineration becomes economical only starting at a minimum capacity of 100 000 tons per year, the favourite option is MBT, which becomes economically interesting already at 20 000 – 30 000 tons a year (and below, with simplified technical conditions). The favourite placement of a MBT is close to the landfill of the municipality.

The overall reduction of biodegradable waste in Bulgaria will be achieved by a **sound and steadily developing combination** of the said measures. This developing process should be aimed at **all regions** of Bulgaria to participate in the progress, thus sharing costs and efforts to reach the aims. Besides the "simple" methods all contributing systems and methods should be **immediately established** by encouraging and supporting **pilot projects**, to make Bulgaria's municipalities familiar with putting the concepts into practice. Further it has to be understood that all measures planned should be scaled to achieve **more** than the pre-calculated reduction (according to the respective reduction steps in 2010/13/20), since reality does not often share completely the (optimistic) visions.

## 4.1 CALCULATION TOOL – "BD –PROGNOSIS BULGARIA"

To develop a concept for the different measures to be applied in order to reduce biodegradable waste in Bulgaria, a calculation tool was prepared allowing different scenarios. Any concept developed has necessarily its inaccuracies; among those critical aspects are the following:

a) The data basis for the calculation of the different waste streams from household, commercial, institutional and industrial sources is too weak. A precise investigation is under preparation at present.

b) The reduction effect of several proposed measures cannot be forecasted exactly.

c) Unknown development in future- investments, new projects and programs.

In simple terms: At present, we do not know precisely where how much organics are produced and how people react if we want them to participate in separate collection.

No doubt, specific frame conditions for the different measures are known by experience. On this basis a concept was developed, allowing a rough calculation of the portion of biodegradable waste constituents to be reduced in the different regions as well as the method proposed.

**This calculation scheme is already in the hands of MOEW Bulgaria enabling it to enter more recent figures in order to update the prognosis and selection of different measures.**

### 4.1.1 DESCRIPTION OF THE EXCEL-SCHEME "BD-PROGNOSIS BULGARIA"

The calculation scheme is organized as follows:

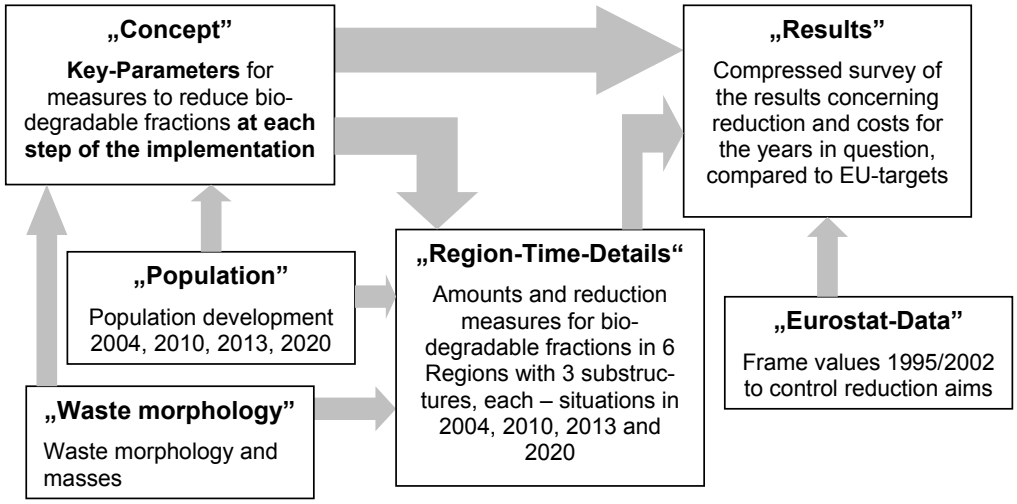



**Figure 20** *Organisation of excel calculation sheet*

***Sheet "results":***

Coming from the end: We want to see whether we reach sufficient reduction of biode-gradable fractions following the EU directive in the years 2010, 2013 and 2020 and the costs incurred. The reduction in the concerned years is achieved by separate collection and treatment of mixed waste by MBT.

The year 2008 is referred to, since some of the "simple" activities (municipal green, paper collection) could be started immediately.

***Sheet "concept":***

**This is the central sheet to deal with.** Three methods for separate collection (of municipal green waste, paper and bio-waste) can be applied by the concerned population. It is the major option to fill in which portion of the population should engage in the respective measures. Frame parameters such as masses and cost of the operation can be changed as well. The costs are estimated in a realistic manner, and outlined as operational costs.

Both, the overall reduction tasks and consequences previously entered are transferred to "results" and to "region-time-details". The efficiency of changes can be controlled under "results".

One exception is the application of MBT. Since some MBT in Bulgaria are already planned, their capacity is to be entered into the "region-time-details" of the concerned region and for the concerned time.

*Sheet "region-time-details"*

For each of the years 2004, 2010, 2013 and 2020 an own calculation scheme has been established, following the same structure and showing several parameters for each of the three substructures for six main regions of Bulgaria.

*Sheet "population"*

The prognosis for the development of the population is entered in this sheet. The population will decrease by about 5 % within the next 10 years; besides a migration to the cities taking place. The three structures "inner city", "suburbs" and "rural" are chosen since they show a specific different reaction when separate collection takes place. Based on research work of SGS Bulgaria, the percentage of suburbs in the cities could be specified for the regions, now.

The mass figures for waste in the top-section "standard parameters" are taken from the sheet **"waste morphology".**

It is first assumed, that each region should install the concerned measures for the **same percentage of concerned population**, therefore this percentage is taken as a standard from the sheet "concept". In the remaining "green" %-fields changes can be made. At the right side of each block, in the blue fields, the values are summed up for Bulgaria.

Based on this calculation, the different measures are described during the implementation progress in the next chapters, including

- the concerned population (inner cities, suburbs, rural)
- the percentage of the population participating in the system, increasing by the time
- the amount of biodegradable waste being reduced by the measures
- the cost of operation per year: total, per ton and per person

All the amounts are provided for the "key" years 2010, 2013 and 2020. The year 2008 has been added to show that some (less cost intensive) measures should be installed quite soon.

## 4.2 MUNICIPAL GREEN WASTE COLLECTION

This simple measure should be started as soon as possible, since the material is - in most cases – already collected separately. **Table 8** shows the planned development. By the year 2010, 70 % of it can already be recycled by simple garden waste composting facilities, coming to a reduction of about 100 000 Mg/a, this to be extended to almost 130 000 Mg/a in the year 2020.

Composting sites can be established close to landfills. In addition, deliveries of pure garden wastes (or other usable organics) from commercial sources are to be excluded from landfills. If the composting facility is not located directly at the landfill, it is possible to position separate containers at the entrance, to directly discharge green waste there.

| **Municipal green waste composting** | | | **Masses kg/Inh, year** | | **25** | |
|---|---|---|---|---|---|---|
| | | | **Invest €/ton,a** | | **200** | |
| | | | **Operating costs** | | **20** | |
| **Parameter** | **unit** | **2004** | **2008** | **2010** | **2013** | **2020** |
| Population part: **Cities** | Number | 5.440.228 | 5.473.816 | 5.490.610 | 5.523.671 | 5.697.410 |
| Municipal Green Waste | Mg/a | 136.006 | 136.845 | 137.265 | 138.092 | 142.435 |
| Separate Reuse | Share | 0% | 50% | 70% | 80% | 90% |
| Green Waste recycled | Mg/a | 0 | 68.423 | 96.086 | 110.473 | 128.192 |
| Invest for Treatment | € | 0 | 13.684.540 | 5.532.595 | 2.877.551 | 3.543.660 |
| Treatment Costs | €/a | 0 | 1.368.454 | 1.921.713 | 2.209.469 | 2.563.835 |
| **Specific costs,reduced ton** | **€/Mg** | **0** | **20** | **20** | **20** | **20** |
| Specific costs | €/Inh,a | 0 | 0,25 | 0,35 | 0,40 | 0,45 |

**Table 8** *Development of municipal green waste composting*

## 4.3 PAPER/CARDBOARD COLLECTION

Paper collection is intended to be installed covering 50%in 2010, already reaching 40 % in 2008. Until 2020, coverage of 90% of the cities' population should be reached.

| **Paper collection** | | | **Masses kg/Inh, year** | | **25** | |
|---|---|---|---|---|---|---|
| | | | **Collection costs €/ton** | | **35** | |
| | | | **Sorting/Recycling €/ton** | | **0** | |
| **Parameter** | **unit** | **2004** | **2008** | **2010** | **2013** | **2020** |
| Population part: **Cities** | Number | 5.440.228 | 5.473.816 | 5.490.610 | 5.523.671 | 5.697.410 |
| Collectable Paper | Mg/a | 136.006 | 136.845 | 137.265 | 138.092 | 142.435 |
| Separate Reuse | Share | 0% | 40% | 50% | 65% | 90% |
| Paper recycled | Mg/a | 0 | 54.738 | 68.633 | 89.760 | 128.192 |
| Collection costs including bins | €/a | 0 | 1.915.836 | 2.402.142 | 3.141.588 | 4.486.710 |
| Sorting/Recycling | €/a | 0 | 0 | 0 | 0 | 0 |
| Total costs | €/a | 0 | 1.915.836 | 2.402.142 | 3.141.588 | 4.486.710 |
| **Specific costs,reduced ton** | **€/Mg** | **0** | **35** | **35** | **35** | **35** |
| Specific costs | €/Inh,a | 0 | 0,35 | 0,44 | 0,57 | 0,79 |

**Table 9** *Development of paper collection*

The mass reduction of paper collection is similar to municipal green waste collection, finally ranging between 90 000 (2013) and 130 000 tons a year (2020).

## 4.4 BIO-WASTE COLLECTION

The collection of bio-waste will - at first - be particularly aimed at the **suburban areas**, housing a population of about 1.6 Mio inhabitants. As explained in chapter 3.5, the highest specific amount of organics – related to the private household – and a good basic motivation for collection are encountered in the suburbs.

Here it is assumed that household waste bins will be emptied on a weekly basis; along with bio-waste collection, both bins are emptied every two weeks. As a result, the collection costs remain almost stable (an increase of 10 €/ton is assumed).

Latest by 2010, the first pilot projects for bio-waste collection should be established to gather experiences. The collected material can be co-composted with the municipal green waste.

As outlined before, the mass of collected bio-waste is higher than the effective reduction (100 kg collected hold roughly 70 kg organic extraction from MSW, the remaining 30 kg are from former backyard composting). By this the effective costs for reduction are 64 €/ton, while the direct costs for collection and treatment are at 45 €/ton

**Table 10** *Development of bio-waste collection*

| | | | | | Collection | Treatment |
|---|---|---|---|---|---|---|
| **Biowaste collection** | | **Reduction of MSW-Organics,kg/Inh, year** | | | **70** | -- |
| | | **Biowaste collected kg/Inh, year** | | | **100** | **100** |
| | | | **Costs for biowaste, €/ton** | | **10** | **40** |
| **Parameter** | **unit** | **2004** | **2008** | **2010** | **2013** | **2020** |
| Population part: **Suburbs** | Number | 1.582.802 | 1.592.574 | 1.597.460 | 1.607.079 | 1.657.627 |
| Reduction Potential in MSW | Mg/a | 110.796 | 111.480 | 111.822 | 112.496 | 116.034 |
| Biowaste-Collection | Share | 0% | 0% | 20% | 50% | 80% |
| Biowaste collected | Mg/a | | 0 | 31.949 | 80.354 | 132.610 |
| Organic reduction in MSW | Mg/a | 0 | 0 | 22.364 | 56.248 | 92.827 |
| Collection costs including bins | €/a | 0 | 0 | 319.492 | 803.540 | 1.326.102 |
| Treatment costs | €/a | 0 | 0 | 1.277.968 | 3.214.158 | 5.304.407 |
| Total costs | €/a | 0 | 0 | 1.597.460 | 4.017.698 | 6.630.509 |
| **Specific costs,reduced ton** | **€/Mg** | **0** | **0** | **71** | **71** | **71** |
| Specific costs | €/Inh,a | 0,00 | 0,00 | 1,00 | 2,50 | 4,00 |

Once established in the suburbs, bio-waste collection will contribute to reduce organics by 80 000 Mg/a. in 2013, increasing to about 130 000 Mg/a in 2020.

Besides the collection in the suburbs, it can be considered to collect commercial organics in the inner cities as well, meaning organics from food discounters, restaurants, florists etc. Related to the single shop, this can be very efficient, especially if efforts are pointed to organising the collection in areas with high concentration of food discounters and restaurants. When these “organic-intensive” locations are singularly diverted in the city, the collection effort can be quite high.

Nonetheless, while implementing the structure for composting of separately recovered material, all single relevant commercial producers of organic waste in the surroundings with the option to hold this material separated should be contacted and motivated to include the concerned material in the recovery line.

## 4.5 STABILIZATION OF BACKYARD COMPOSTING

Recent pilot projects to support home composting reveal costs of roughly 90 - 150 EUR/ composter. This is rather high, since the number of composters is quite small, all are imported, and additional start-up costs and administration increase the specific price. At a broader scale application, and when the production of composters is possible in Bulgaria itself, a lower prize of presumably 60 € appears more realistic.

| Parameter | Unit | City suburbs | Rural |
|---|---|---|---|
| Specific mass in waste | kg/cap./y | 100 | 30 |
| Specific mass to recover | kg/cap./y | 30 | Avoiding an increase of 30 kg/cap./y |
| **Information** - specific costs | €/cap./y | 1.1 | 1.1 |
| **Free composting bins** | | | |
| Specific investment costs (4 % participation, 4 Pers/composter, 60 €/composter), | €/cap. | 2.4 | 2.4 |
| Specific annual costs, 5 years | €/cap./y | 0.48 | 0.48 |
| Total annual costs | €/cap./y | 1.58 | 1.58 |
| Specific system costs (without benefits from waste treatment costs) | €/ton | 53 | (53) |
| Concerned Part of Population | Number | 1 600 000 | 2 000 000 |

**Table 11** *Frame parameters for supporting home composting*

Further more support for "**on-farm composting"** should be provided for rural communities/areas. Due to adoption of new legislation /Waste Management Act and its supplementary normative documents; Law for Agricultural Lands Restoration and Use, as well as the liquidation of industrial cattle breeding, which has led to the accumulation of great amounts of manure in private farms, the existing small local rural depots - legally constructed years ago - become illegal entities and impossible to modernize in compliance with the new requirements.

Consequently, municipal administrations had to undertake a policy for solving these problems. Local initiatives started three years ago in 7 villages of municipalities of Boljarovo, Tundja and Granitovo. The first stage of the Project began with cleaning the depots and establishing of areas for waste collection and recycling. The idea was to set up composting sites on the former depot terrains while using the custom of the population to take the household and farm waste to the existing landfills themselves. The site was divided on two- one for organic waste from gardens and animal breeding, the other for other type of waste which people are not allowed or not has space to put in their bins (old dresses, furniture, tires). On the site container were placed for other waste from 1100 L or from 4 $m^3$.

The organic waste is turned periodically -in general the municipalities turn the piles of organic waste once per month - and in a year or more people can make use of the composted product. The other waste is transported to the regional landfill. Recently more than 20 villages have shown interest to this practice and have applied for funding for establishing "areas for waste collection and recycling". - (in some villages they are). The idea is to continue to use the people's habit to bring their waste on the site, but they have to separate it in two fractions. The advantages for the villages is

- the reduced transport cost, and taking advantage of the peoples habit (as most of the people living in these rural areas are over 50 years old and with lower education status)
- the production of some compost/ stabilized manure.

Unfortunately at the moment these site do not comply with all normative regulations. For instance:

- according to the Waste Management Act any waste treatment site (which actually is done in this case- as composting is performed) needs to be registered and the owner (operator) should have permit from the Regional Environmental Inspectorate on which territories it is located (Art. 12 from Waste Management Act)
- The biodegradable materials are put directly on the earth and this can cause soil contamination from the leachate;
- With entering into force of Regulation 50 for veterinarian requirements to animal by products not intended for human consumption of the Ministry of Agriculture and Forestry there will be more stringent requirements for composting of manure;

Taking into account that currently there is no capacity for treatment of organic wastes from households it will be essential to support “on-farm-composting”. Support will be needed for making the site to comply with normative regulations.

## 4.6 MBT-TREATMENT AND INCINERATION

The mechanical-biological-treatment (MBT) or incineration of the remaining MSW should close the gap between the already achieved reduction of biodegradable waste by separate collection and the needed decrease to obtain the concerned total reduction. The capacities of MBT (or incineration for the biggest cities) are therefore based on the reduction efficiencies of the other “collecting” measures and – of similar importance – on the running investigations of the actual amount of biodegradable waste in the different waste streams.

Since the data basis is not finally confirmed for both, the estimation of MBT-capacity is a roughly calculated figure to meet the reduction demands in this scenario. Any decision (esp. by the bigger cities) to build MSW-treatment capacity can influence the scenario extremely – esp. in the case of Sofia.

MBT and incineration is the most expensive measure to reduce organics, since the complete waste is passing the facility. At MBT the waste is screened, grinded, sorted, and the greater part of the non-organics is passed to the landfill (where it could have been disposed without prior treatment as well). Of course it is possible to make use of the high calorific compounds and sorted material, but in the near future it is likely that this option is more expensive than bringing on landfill.

**Table 12** *Development of MBT – Treatment*

| **MBT - Treatment** | | **Treatment cost €/ton MSW** (incl. landfill costs for treated BD, without disposal of residues) | | | **50** | |
|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **2004** | **2008** | **2010** | **2013** | **2020** |
| Population part: **Cities** | Number | 5.440.228 | 5.473.816 | 5.490.610 | 5.523.671 | 5.697.410 |
| Remaining BD in MSW | Mg/a | 1.362.719 | 1.246.411 | 1.188.257 | 1.127.140 | 1.077.930 |
| *MSW treated in MBT* | *Mg/a* | *0* | 0 | *0* | *520.653* | *957.616* |
| BD treated in MBT | Mg/a | 0 | 0 | 0 | *259.611* | *468.072* |
| BD treated in MBT | Share | 0% | 0% | 0% | 23% | 43% |
| Treatment costs | €/a | 0 | 0 | 0 | 26.032.671 | 47.880.788 |
| **Specific costs,reduced ton** | **€/Mg** | **0** | **0** | **0** | **100** | **102** |
| Specific costs | €/Inh,a | 0,00 | 0,00 | 0,00 | 4,71 | 8,40 |

Arriving on this – indeed simplified – point of view, the most efficient way to use MBT is to operate it by waste containing high (remaining) biodegradable fractions. This applies in particular to the waste collected in the city centres and suburbs with no established bio-waste collection. MSW from rural areas and suburbs with bio-waste collection systems contains a much lower portion of organics that it can be brought on landfill directly – as long as there are "inner city" charges available for treatment.

As outlined in chapter 3.7.1, an operating waste incineration facility for the city of Sofia (approx. 350 000 Mg/year) in 2013 would cover the treatment demand for mixed waste in Bulgaria after a reduction of biodegradable waste fractions of almost 150 000 Mg/year.

## 4.7 MINIMIZING LANDFILLED SEWAGE SLUDGE

As outlined in chapter 2, sewage sludge is by formal reasons not part of the reduction concept. Nonetheless, sewage sludge should be reused in agriculture or be treated to avoid similar negative impacts when landfilled as the "included" solid biodegradable fractions of MSW.

Three options are available to reduce sewage sludge going to landfill by:

- agricultural use
- co-treatment in MBT
- incineration (favourably in existing coal – incinerators)

Following first estimations, 40 % of the produced sewage sludge is usable in agriculture or for re-naturing of waste areas, which is assumed to be less costly compared to other treatment methods. At first has to be achieved better quality of the sludge by more stringent standards for discharging of waste water from industrial sources in the municipal seweary system and providing of treatment of all sewage sludge.

**Table 13** *Development of Sewage Sludge – Reuse and Treatment*

| | | | | | Share | Costs €/ton |
|---|---|---|---|---|---|---|
| **Sewage Sludge - Treatment** | | **Dry mass in sludge:** | **agricultural use** | | s.Listing | **50** |
| | | | **MBT - Treatment** | | 40% | **70** |
| | | 30% | | **Incineration** | 60% | **80** |
| | | | **Average MBT/Incinerat.** | | 100% | **76** |
| **Parameter** | **unit** | **2004** | **2008** | **2010** | **2013** | **2020** |
| Pop. connected to WWTP | Number | 3.200.000 | 3.400.000 | 3.500.000 | 3.966.000 | 4.362.600 |
| Produced Sewage Sludge, wet | Mg/a | 299.750 | 338.250 | 357.500 | 397.815 | 437.597 |
| add. Sludge, comp. to 2002 | Mg/a | 0 | 38.500 | 57.750 | 98.065 | 137.847 |
| Produced Sewage Sludge, dry | *Mg/a* | *89.925* | *91.328* | *91.163* | *89.508* | *91.895* |
| Agricultural use | Share | 0% | 10% | 15% | 25% | 30% |
| Agricultural use | Mg/a wet | 0 | 33.825 | 53.625 | 99.454 | 131.279 |
| Non used remaining sludge | Mg/a | 299.750 | 304.425 | 303.875 | 298.361 | 306.318 |
| MBT/Incineration (of total sludge) | Share | 0% | 0% | 10% | 30% | 60% |
| MBT/Incineration (of total sludge) | Mg/a wet | 0 | 0 | 35.750 | 119.345 | 262.558 |
| **Total reduction** | **Mg/a wet** | **0** | **33.825** | **89.375** | **218.798** | **393.837** |
| Sludge to landfill | Mg/a wet | 299.750 | 304.425 | 268.125 | 179.017 | 43.760 |
| **Costs** Agricultural use | €/a | 0 | 1.691.250 | 2.681.250 | 4.972.688 | 6.563.948 |
| MBT-Treatment/Incineration | €/a | 0 | 0 | 2.717.000 | 9.070.182 | 19.954.400 |
| **Total costs** | €/a | 0 | 1.691.250 | 5.398.250 | 14.042.870 | 26.518.348 |
| **Specific costs,reduced ton** | **€/Mg** | **0** | **6** | **18** | **47** | **87** |
| Specific costs, direct/indirect | €/Inh,a | 0,00 | 0,50 | 1,54 | 3,54 | 6,08 |

## 4.8 COSTS OF THE MEASURES IN COMPARISON

From an economic point of view, it is clear that reduction of biodegradable waste should take place at minimized cost.

When reviewing the previous tables listing the different treatment measures we can set three groups of activities incurring specific total costs (including capital costs) to reduce one ton of biodegradable waste **(subsidiaries, e.g. ISPA funding, not calculated)**:

**Low cost, under 50 €/ton:** municipal green waste composting, paper collection, (agricultural use of sewage sludge)

**Medium cost, 50 to 90 €/ton:** bio-waste collection, (sewage sludge treatment by incineration or MBT)

**High cost, above 90 €/ton:** MBT or incineration of mixed MSW[4]

Coming from this hierarchy of costs, it is clear that all "less expensive" measures should be employed to full extend before making use of the more expensive ones. This was considered when establishing the calculated development of the different measures.

[4] Important note: This statement is related to the integrated treatment of biodegradable fractions, only. Of course MBT and incineration have other specific advantages esp. saving of landfill volume, energy recovery etc.

These amounts do not include the savings of landfill costs. These savings differ, depending on the extent of the reduction of biodegradable waste in landfill. As later shown in Chapter 5, **Table 14**, the estimated saved cost are set on a low level – 10 € per ton, which can be considered as the pure reduced costs for operation. It must clearly be said that the first measures of separate collection and reuse of biodegradable do not substantially affect the landfill equipment, reducing cost e.g for gas collection, gas flares or leachate collection and treatment. A gas collecting system is necessary, no matter whether the landfilled waste produces 100 or 300 m³/ton. Only if almost the complete biodegradables are eliminated – which can only be obtained by a complete treatment by incineration or MBT, the remaining gas production goes down to a level where a gas collection is no longer necessary.

Thus, the first operative savings from reduced landfill are – latest at introducing the biowaste collection - not sufficient enough to give an economical incentive for the reduction measures. In this respect, the government has two main options to choose:

- Legislative restriction: Charges with a relevant organic content are **excluded from landfilling** (e.g. Green yard waste, manure etc.)

- Economical restriction: The costs of landfill are artificially increased - by a landfill tax. In case that landfilling charges the user not only with “real” costs, but with an additional fee of lets say 15-20 €/ton, this will produce much more willingness for any reducing measures – by simple economical mechanisms.

Since the landfill tax had been established in many European countries, it will be described in the next chapter.

## 4.9 ESTABLISHMENT OF A LANDFILL TAX

Taxes (or levies) on waste amounts being delivered at landfill are supposed to represent an efficient steering tool to divert biodegradable (or other recyclable) waste streams prior to final disposal.

**Figure 21** shows that landfill taxes are used in many EC member states. In new member states it is much less common: At present the Czech Republic only makes some serious attempt to implement such an instrument.

### 4.9.1 HOW TO DESIGN AND APPLY A LANDFILL TAX

**A landfill tax can be collected on, both, municipal and state / national level.**
In the light of the present overall task - implementation of a legal matter imposed by a European institution - and assuming the institutional capacities of the municipal level it seems to more recommendable to collect the tax by some national administration.

Basically it remains the choice of the municipal level to collect their own landfill taxes (in addition to a national tax), e.g. as compensation for a municipality which contributes a landfill site.

**The height of the tax (levy) should be oriented at the prevailing disposal (landfilling) cost.**
Between a third and half of the average gate fee on landfills with reasonable to upper standard (example: Plovdiv) seems to be a reasonable portion.

**For proper planning there should be a clear and reliable pattern regarding the time-dependant increase** (e.g. 2006 - 2008 10 €/t, 2008 - 2012 20 €/t etc.) - waste industry likes a n d needs clear calculation benchmarks. Any uncertainties are a considerable impediment for investment decisions.

**The landfill tax should be made dependable on weight** (x €/t).
Operators of landfills without weighbridges will report to the relevant authority delivered volumes. These volumes get multiplied by a *uniform bulk density*. Reported volumes will be at the lower end (this experience was made at least in Austria); for compensation the applied bulk density should be chosen from the higher end, eg. 0,3 t/m$^3$ domestic waste.

**The collected tax / levy might be used for**

- *Promoting various kinds of waste management activities* (PR, financial support for technical infrastructure for composting separately collected biodegradable materials)
- *Remediating brown fields / improper waste disposal sites* (example: Austria)

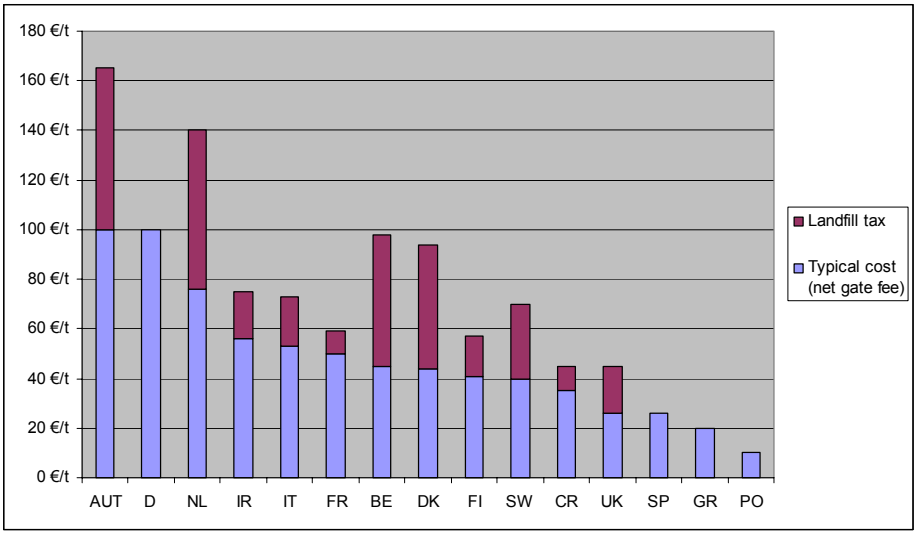



**Figure 21** *Overview on typical landfill cost & taxes in Europe*

(slightly adapted from "Cost-Benefit Analysis for Residual Waste Treament", presentation held by Dr D. Hogg at the Conference "The Future of Residual Waste Management in Europe", November 2005, Luxembourg)

### 4.9.2 EXAMPLE AUSTRIA

The example of Austria - landfill tax for untreated MSW at present 65 €/t, from January 1 2006 onward 87 €/t - shows that a landfill tax (introduced at first in 1988) shows a good result in respect to the diversion of recyclable waste streams (Figure 23), also at low values (about 7 €/t until 1999) - which makes clear that other measures had and have to taken in parallel of course, to set an incentive..

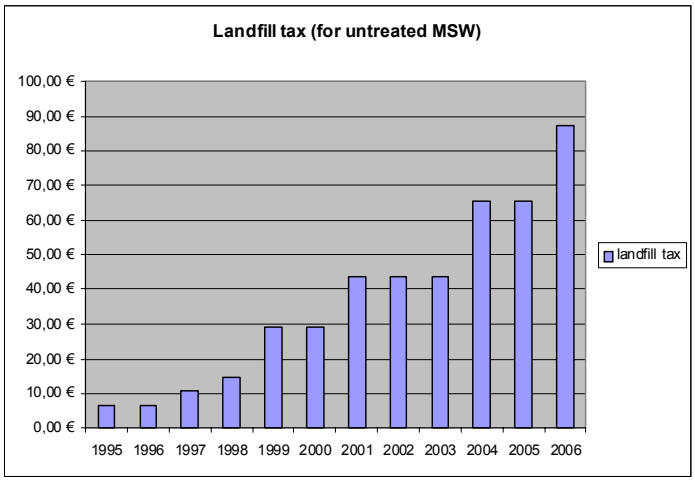



**Figure 22** *Development of the Austrian landfill tax*

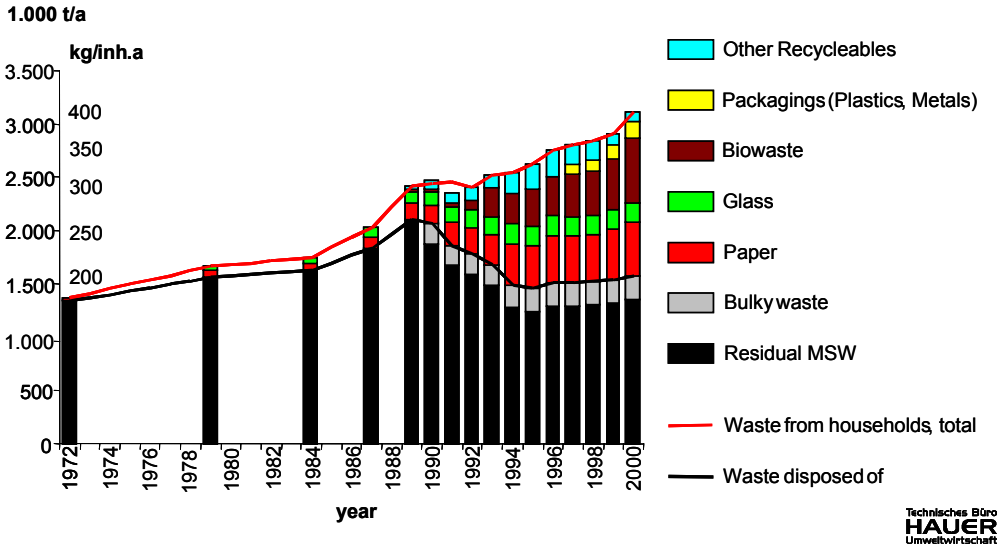



**Figure 23** *Austria's "waste history" 1972 - 2000*

In fact, the landfill tax has partly to be collected anyway to cover the unavoidable later cost of a landfill, meaning the costs for finalizing the landfill with covering the long term monitoring, gas and leachate treatment, lasting for several decades. This has often been "forgotten" in the real costs calculation of a landfill, coming to the end that in some ten or twenty years the citizens are not only charged then with the elaborated and more costly treatment and collecting system, but as well with the landfill costs not covered by the generation before.

At any rate, the installation and esp. the increase of the landfill tax over the years must provide the chance to install the alternatives for the communities – this to make the landfill tax a real incentive instrument for avoidance and recycling. The stepwise increase e.g. in Austria (see **Figure 22**) going parallel with the recycling measures (see **Figure 23** ) is a good example for a realistic steering function of this tax.

# 5 MEETING THE TARGET OF EU-LANDFILL DIRECTIVE

The development of the individual measures described before is listed in the table below, making thereby possible to compare the total reduction to the targets set by the EU-Landfill Directive. Origin and reduction of sewage sludge – formally not included – is implemented in the table, but not part of the reduction calculation.

**Table 14** *Results of reduction measures*

| Parameter | unit | 1995 | 2002/4 | 2008 | 2010 | 2013 | 2020 |
|---|---|---|---|---|---|---|---|
| Population | Number | 8.384.715 | 7.801.273 | 7.623.404 | 7.534.469 | 7.420.076 | 7.343.884 |
| Originated MSW | Mg/a | 4.495.000 | 3.199.360 | 3.158.125 | 3.137.507 | 3.113.263 | 3.127.600 |
| **Originated BD of MSW** | **Mg/a** | **2.247.500** | **1.631.679** | 1.616.119 | **1.608.340** | **1.599.811** | **1.614.839** |
| *add. Sewage sludge* | *Mg/a* | *n.a.* | *299.750* | *338.250* | *357.500* | *397.815* | *437.597* |
| Reduction by measures: | | 0% | 0% | 0% | 0% | 0% | 0% |
| Municipal green waste coll. | Mg/a | 0 | 0 | 68.423 | 96.086 | 110.473 | 128.192 |
| Paper collection | Mg/a | 0 | 0 | 54.738 | 68.633 | 89.760 | 128.192 |
| Biowaste collection | Mg/a | 0 | 0 | 0 | 22.364 | 56.248 | 92.827 |
| **Total reduction by collection** | Mg/a | **0** | **0** | **123.161** | **187.083** | **256.481** | **349.211** |
| *Sewage sludge use/treatment* | *Mg/a* | *0* | *0* | *33.825* | *89.375* | *218.798* | *393.837* |
| Remaining BD in MSW | Mg/a | 2.247.500 | 1.631.679 | 1.492.958 | 1.421.257 | 1.343.330 | 1.265.628 |
| MBT/Incineration of MSW | Share | 0% | 0% | 0% | 0% | 19% | 37% |
| MBT/Incineration of BD | Mg/a BD | 0 | 0 | 0 | 0 | 259.611 | 468.072 |
| *MBT/Incineration of MSW* | *Mg/a total* | *0* | *0* | *0* | *0* | *520.653* | *957.616* |
| **Total Reduction of BD** | **Mg/a** | **0** | **0** | **123.161** | **187.083** | **516.092** | **817.283** |
| **Remaining BD to landfill** | **Mg/a** | **2.247.500** | **1.631.679** | **1.492.958** | **1.421.257** | **1.083.719** | **797.556** |
| *Remaining MSW to landfill* | *Mg/a* | *4.495.000* | *3.199.421* | *3.034.964* | *2.950.424* | *2.597.171* | *2.310.317* |
| **Landfilled BD, rel. to 1995** | **Share** | **100%** | **73%** | **66%** | **63%** | **48%** | **35%** |
| ***Task following EU-guideline*** | ***Share*** | ***0%*** | ***0%*** | ***0%*** | ***75%*** | ***50%*** | ***35%*** |
| *Costs separate coll./treatm.* | *T€/a* | *0* | 0 | 3.284 | 5.921 | 9.369 | 13.681 |
| *Costs MBT treatment* | *T€/a* | *0* | 0 | 0 | 0 | 26.033 | 47.881 |
| *Costs sewage sludge* | *T€/a* | *0* | *0* | 1.691 | 5.398 | 14.043 | 26.518 |
| *Saved Landfill costs* | *T€/a* | *0* | 0 | -1.232 | -1.871 | -5.161 | -8.173 |
| **Total Treatment costs** | **T€/a** | **0** | **0** | **2.053** | **4.050** | **30.241** | **53.389** |
| *Specific costs per Inhabitant* | *€/Inh, year* | 0 | 0 | 0,27 | 0,54 | 4,08 | 7,27 |

The extent of the different reduction measures is adjusted in order to reach the targets, mostly keeping a certain buffer. It is obvious that the reduction in 2010 is considerably higher than demanded, but exactly this should be aimed for three reasons:

1) **The measures leading to this result are not cost intensive** – mostly based on separate municipal green waste and paper collection, already leading to a reduction of about 150.000 Mg/year.
2) **Stepwise implementation to gather experience:** It appears quite risky to wait until 2010 with the implementation of any measure and then to try to install a reduction capacity to go in full operation in 2013 with an assumed reduction of 600.000 tons a year.
3) **Acceptance by population:** Implementing organic reduction measures quite soon helps to start the development of an environmental awareness, resulting as well in an increasing tolerance concerning additional costs.

The costs of the reduction measures are not very frightening. In the calculated average they are below 1 €/cap/year in 2010, rising to max. 6 – 8 €/cap/year, this including the capital costs, but not including eventual reductions by substantial EU-support for the investments. Anyway, there will be a substantial increase of costs in 2013, almost doubled again in 2020. Then, there should not be an additional need to increase the fees to cover the costs for the landfills then being closed. All the money needed for the closing and later monitoring of the landfills should then have been collected by a sound landfill tax in the years before.

# 6 MEASURES PER REGION

The reduction measures, shown in **Table 14** at a nationwide scale, should be differentiated concerning the share that each of the six regions of Bulgaria should contribute. These shares are calculated in

**Table 15**, outlining the reduction capacities in the regions for the concerned components in the years 2010, 2013 and 2020.

In general, the reduced amounts are related to the specific share of a certain dwelling structure's population in the concerned region. Detailed tables for the years and the regions are presented in the appendix, including the population status in the regions.

In each of the three year-blocks in

**Table 15**, the first three lines describe the primary production of biodegradable waste from two sources, solid MSW and sewage sludge. Summed up horizontally, the total amounts are the same as in **Table 14**. The distribution of sewage sludge is depending on the share of urban population in the regions (e.g. North-West 5.5 %, South-West 31.5 %).

The next four lines describe the required reduction for separate collection of green yard waste, paper and bio-waste.

Below, the added treatment capacity by incineration or MBT for biodegradable compounds in MSW are figured, meaning that the capacities of these facilities for total MSW are at least twice as high.

Moreover, the total amount of sewage sludge treated or used in agricultural and the percentage of agricultural application and treatment by incineration or MBT are not defined, here, since this depends on the different qualities of the sludge – lower in industrialized areas, higher in almost pure housing structures.

The bottom lines show the regional task in total reduction of biodegradable waste fractions, which is the most important figure for each region, no matter by which way it is achieved.

***Each figure in this table - as in the other concerned tables as well - has a numeric accuracy, which will not be met in reality. This accuracy is only used to make the calculation transparent and consistent.***

**Table 15** is based on the assumption, that in 2013 the incineration of Sofia (South-West) and the MBT installations of Plovdiv (South Central) and Rousse (North Central) are in operation. If this is the case, no additional MBT-activities are needed in the other regions, as long as each of these regions fulfils their reduction tasks in the other action fields.

**Table 15** *Shares of the regions to fulfil the nationwide reduction targets*

| **2010** - Tons per year | North West | North - Central | North - East | South-East | South-Central | South-West | Total |
|---|---|---|---|---|---|---|---|
| **Total BD of MSW** | ***96.745*** | ***236.695*** | ***250.251*** | ***162.206*** | ***391.886*** | ***470.556*** | ***1.608.340*** |
| *Sewage sludge* | *19.840* | *51.942* | *54.077* | *35.230* | *83.819* | *112.591* | *357.500* |
| Collected green waste | 5.332 | 13.960 | 14.534 | 9.469 | 22.528 | 30.261 | 96.086 |
| Collected paper | 3.809 | 9.972 | 10.382 | 6.764 | 16.092 | 21.615 | 68.633 |
| Collected biowaste *) | 2.369 | 4.895 | 7.008 | 2.133 | 6.514 | 9.030 | 31.949 |
| **Reduction by collection** | 10.800 | 27.359 | 29.822 | 17.726 | 43.180 | 58.197 | 187.083 |
| BD to Incineration/MBT | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Reduction of BD** | **10.800** | **27.359** | **29.822** | **17.726** | **43.180** | **58.197** | **187.083** |
| *Sludge use or treatment* | *4.960* | *12.985* | *13.519* | *8.808* | *20.955* | *28.148* | *89.375* |
| BD (MSW) to landfill | 85.945 | 209.337 | 220.429 | 144.481 | 348.706 | 412.359 | 1.421.257 |

| **2013** - Tons per year | North- West | North - Central | North - East | South - East | South-Central | South-West | Total |
|---|---|---|---|---|---|---|---|
| **Total BD of MSW** | ***96.131*** | ***235.399*** | ***248.756*** | ***161.356*** | ***389.706*** | ***468.464*** | ***1.599.811*** |
| *Sewage sludge* | *22.078* | *57.799* | *60.175* | *39.203* | *93.272* | *125.288* | *397.815* |
| Collected green waste | 6.131 | 16.051 | 16.711 | 10.887 | 25.902 | 34.793 | 110.473 |
| Collected paper | 4.981 | 13.041 | 13.577 | 8.846 | 21.045 | 28.269 | 89.760 |
| Collected biowaste *) | 5.959 | 12.311 | 17.626 | 5.364 | 16.383 | 22.711 | 80.354 |
| **Reduction by collection** | 15.284 | 37.710 | 42.626 | 23.487 | 58.415 | 78.959 | 256.481 |
| BD to Incineration/MBT | 0 | 18.922 | 0 | 0 | 65.809 | 174.880 | 259.611 |
| **Total Reduction of BD** | **15.284** | **56.632** | **42.626** | **23.487** | **124.224** | **253.839** | **516.092** |
| *Sludge use or treatment* | *12.143* | *31.789* | *33.096* | *21.562* | *51.299* | *68.908* | *218.798* |
| BD (MSW) to landfill | 80.847 | 178.767 | 206.130 | 137.868 | 265.483 | 214.624 | 1.083.719 |

| **2020** - Tons per year | North- West | North - Central | North - East | South - East | South-Central | South-West | Total |
|---|---|---|---|---|---|---|---|
| **Total BD of MSW** | ***98.166*** | ***238.093*** | ***255.616*** | ***160.625*** | ***390.988*** | ***471.350*** | ***1.614.839*** |
| *Sewage sludge* | *24.285* | *63.579* | *66.193* | *43.124* | *102.599* | *137.817* | *437.597* |
| Collected green waste | 7.114 | 18.625 | 19.391 | 12.633 | 30.056 | 40.373 | 128.192 |
| Collected paper | 7.114 | 18.625 | 19.391 | 12.633 | 30.056 | 40.373 | 128.192 |
| Collected biowaste *) | 7.359 | 19.267 | 20.059 | 13.068 | 31.092 | 41.764 | 132.610 |
| **Reduction by collection** | 19.380 | 50.737 | 52.823 | 34.414 | 81.876 | 109.981 | 349.211 |
| BD to Incineration/MBT | 24.437 | 63.977 | 66.607 | 43.394 | 103.241 | 166.416 | 468.072 |
| **Total Reduction of BD** | **43.818** | **114.714** | **119.431** | **77.807** | **185.117** | **276.396** | **817.283** |
| Sludge use or treatment | 21.857 | 57.221 | 59.574 | 38.811 | 92.339 | 124.035 | 393.837 |
| BD (MSW) to landfill | 54.349 | 123.379 | 136.186 | 82.818 | 205.871 | 194.954 | 797.556 |

*) Biowaste mass is higher than the reduction effect, therefore the sum of reduction is lower than the sum of collected material

In 2020, the activities for separate collection are planned to be extended to all regions at the same proportion, nonetheless leaving an additional treatment demand for mixed MSW. South-West (Sofia) holds its incineration/MBT-capacity installed already in 2013, the other regions are asked to install or expand their capacities for reduction of biodegradable fractions in mixed waste, this being achieved by treating about 50 % of the (still high organic) central city's waste by incineration or MBT.

Basically and as already mentioned, the regions are free to achieve a certain reduction target by different proportions of the various activities, based on their specific conditions. The figured sub-targets of the different reduction options are considered to be useful, since the concerned municipalities will collect their experience for all options, thereby putting further decisions on a broader basis of specific knowledge and experience.

# 7 RECOMMENDED ACTION PLAN

In conclusion of the chapters above the recommended steps are as following

**Short-term measures (2006 -2008)**

- Stabilization and support of any running an planned activities leading to a reduction of biodegradable waste going to landfill
- Establishing a green yard waste composting system, in 2008 recovering 50 % of this type of organics, with focus on lager cities. When established, support by excluding pure organic waste from landfilling
- Establishing of a paper collection system, first focus on larger cities, to let 40 % of the population take part on collection of paper
- Increase and supervision of support for home- and on-farm composting
- Initiation of first collection pilot projects in suburbs for biowaste collection
- Establishing a concept for landfill tax and application in the regions where alternatives for reduction already exist
- Training concept for municipalities to become familiar with the administrative and technical options for an increased recycling
- Public information/education campaign on environmental awareness, including methods and recycling options waste treatment
- Conduction and evaluation of waste morphology research to get a clear survey on masses and reduction potentials

**2008 to 2010**

- Agreement/Directive for the implementation of actions and facilities in the regions including allocation concept to meet the reduction targets in 2013.
- Increasing of green yard waste and paper collection to a recovering rate of 70 resp. 50 %
- Check of the waste in rural areas for organics to qualify the effect of support measures for home composting

- Installation of biowaste collection in 20 % of the suburbs; including organic wastes from restaurants and (super)markets (in pilot project first)
- Supervision of the developments of planning and installation of the incineration/MBT – capacities to be ready in 2013
- Continuous evaluation of all already existing pilot projects and facilities
- Continuing in public education work
- Development of expanded markets to make use of high-calorific residues from MBT

**2010 to 2013**

- Increasing of green yard waste and paper collection to a participation rate of 80 resp. 65 %
- Installation of biowaste collection in 50 % of the suburbs, including organic wastes from restaurants and (super)markets
- Supervision of the developments in installation of the incineration/MBT – capacities to be ready in 2013
- Agreement/Directive for the implementation of actions and facilities in the regions including allocation concept to meet the reduction targets in 2020.

**2013 to 2020**

- Increasing of green yard waste and paper collection to a participation rate of 90 %
- Installation of biowaste collection in 80 % of the suburbs, including organic wastes from restaurants and (super)markets
- Supervision of the developments in installation of the incineration/MBT – capacities to be ready in 2020

# 8 CONCLUSION

Bulgaria will completely fulfil the requirements of the EC Landfill Directive in reducing the amount of biodegradable waste in three steps to 75 % (2010), 50 % (2013) and 35 % (2020), related to the amount of biodegradable waste on landfill in 1995. The Bulgarian legislation is fully equipped to perform the needed proceedings.

A national strategy for the reduction of biodegradable wastes was to be established.

Following EUROSTAT-Figures, **in 1995 2.25 Mio tons** of biodegradable waste were going on landfill in Bulgaria, being reduced to recent **1.63 Mio tons** (**2002**, last available official figure). Based on these figures, the reduction target of 2010 with 75 % appears to have been reached already and has to be further reduced to **1.12 Mio tons in 2013** and to **0.79 Mio tons in 2020,** respectively.

Thereby the **reduction demand** jumps up in **2013 to about 476 000 Mg/a**, compared to the recent status, followed by an increase to **828 000 Mg/a in the year 2020**.

As described in the implementation concept, **the fact that the reduction aim of 2010 has *arithmetically* already been reached at present should not lead to the conclusion that no further activities are necessary in the upcoming years.** On the one hand there are several options given to reduce biodegradable fractions in the short term which can be realized at low additional cost, leading to a significant ecological benefit. Further, experiences show that the upcoming demand for reduction of 476 000 Mg/a by 2013 cannot be realized “just-on-time”, so an at least stepwise reduction before 2013 is recommended. Besides, the remaining time before 2013 is certainly needed to gather specific experiences with different reduction methods and their technical and administrative characteristics, this enabling the national and local administrations to select the most effective systems and combination of reduction measures for further implementation. Finally, there is an - only formally excluded - amount of landfilled sewage sludge in 2010, with 357 000 Mg/a almost five times higher than the surplus of already achieved reduction of the biodegradable solid waste.

The following options to reduce biodegradable components were described:

Measures by **separate collection** and treatment of

- Municipal green yard waste
- Paper/cardboard
- Organic kitchen and private garden waste (“bio-waste”)
- Rural areas: Stabilization of the motivation for backyard composting and animal feeding with kitchen and garden waste
- Financial support for home composting to stabilize the recent low level of organics in the waste of rural areas.

Measures by **treating the remaining mixed** waste

- Incineration
- Mechanical/biological (and thermal) treatment

Reduction effect, applicability and costs of these measures depend mainly **on the type of dwelling structure**. Thus, the different reduction options were related to the structures “inner city”, “suburbs” and “rural” areas.

Moreover, options to treat **sewage sludge** were described. Sewage sludge is formally not part of the EU-Landfill-Directive, therefore excluded from the reduction calculation. Nonetheless it should be considered, that sewage sludge shows the same negative

ecological impact when landfilled as the biodegradable fractions in solid waste. Due to the ongoing installation and operation of waste water treatment plants, sewage sludge masses will increase from now 300 000 Mg/a to about 440 000 Mg/a in 2020 (30 % dry substance assumed). A nationwide reuse and treatment concept should be developed aside from the formal demands of the landfill directive.

For the prognosis and development of the reduction concept a **calculation tool** was established, integrating all important variables such as population development in different dwelling structures, waste morphology, degree of application of the different reduction measures, specific cost, etc. This calculation tool was given to MOEW Bulgaria enabling it to enter more recent figures to come to an adapted prognosis and selection of different measures.

The **concept** first activates “less expensive” measures until 2013 and afterwards adds the more expensive ones:

- **Collection of green yard waste and composting** should be implemented at first and will reach a reduction of 100 000 to 130 000 Mg/a.
- **Paper and cardboard collection** should be installed soon as well, stepwise reducing the biodegradable waste fraction in the range of 70 000 to 130 000 Mg/a.
- **Bio-waste collection** should be started in pilot project in suburbs, being calculated to collect kitchen wastes and garden wastes in the range of 80 000 – 130 000 Mg/a.
- **Support of home composting** is already established in several rural communities, not likely to produce a reduction, but – not less important – avoids an increase of organics in the waste of these regions.
- Large scale reduction of biodegradable fractions in **mixed waste** is expected for 2013 by the (expected) **incineration plant** of Sofia and the projected **MBT** of Plovdiv. If they do not achieve their specific reduction tasks by other means, all regions of Bulgaria **will need MBT or incineration** capacities for at least 50 % of their mixed waste until 2020, then in total reducing the biodegradable fraction by mixed waste treatment in the range of 470 000 Mg/a.
- A **landfill tax** for mixed solid waste is recommended, this forming an economical incentive for reducing and recycling measures
- Aside of the formal Landfill Directive demands **sewage sludge** should either be conditioned for agricultural use (if heavy metal contents allow) or be treated by thermal or biologic methods before being brought on landfill.

Based on the respective percentage of population, the nationwide targets were broken down to **reduction tasks for the six regions in Bulgaria**, setting sum target figures for the concerned years 2010, 2013 and 2020 and differentiating these again in sub-targets for the different reduction options mentioned above.

The costs for the implementation of the concept are comparatively low. Applying the first measures until 2010, the total costs will in average not exceed 1 €/cap/year. Afterwards, the specific cost will increase to about 6 - 8 €/cap/year (not calculating financial support for the investments by the EU).

With the help of the scheduled measures, Bulgaria will finally reach in the year 2020 a reduction of the original biodegradable waste in the range of 1 000 000 tons a year, thereby not only fundamentally reducing the negative emissions from landfills, but as well recovering energy and improving soil quality by extended recycling and qualified sustainable treatment.

# *Appendix*

## **Appendix A** *Region-wise status in 2004*

| 2004 | | South-East | | year: | 2004 | South-Central | | year: | 2004 | South-West | | year: | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** |
| Population | Number | 430.448 | 105.669 | 246.536 | 782.653 | 952.810 | 322.705 | 668.867 | 1.944.382 | 1.265.994 | 447.355 | 396.687 | 2.110.036 |
| Originated MSW | Mg/a | 211.350 | 44.592 | 66.565 | 322.507 | 467.830 | 136.182 | 180.594 | 784.605 | 621.603 | 188.784 | 107.105 | 917.492 |
| Originated BD Waste | Mg/a | 94.268 | 19.232 | 20.462 | 133.962 | 208.665 | 58.732 | 55.516 | 322.914 | 277.253 | 81.419 | 32.925 | 391.596 |
| **"Green" waste coll.** | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Inhabitants | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Collected green waste | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Paper collection** | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Inhabitants | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Collected paper | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Biowaste collection** | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Inhabitants | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Collected biowaste | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Reduction of BD | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Reduction by collection** | Mg/a | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Remaining BD in MSW | Mg/a | 94.268 | 19.232 | 20.462 | 133.962 | 208.665 | 58.732 | 55.516 | 322.914 | 277.253 | 81.419 | 32.925 | 391.596 |
| MBT-Treatment of MSW | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| MBT-Treatment of BD | Mg/a BD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *MBT-Treatment, MSW* | *Mg/a total* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| **Total Reduction of BD** | **Mg/a** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Remaining BD to landfill | Mg/a | 94.268 | 19.232 | 20.462 | 133.962 | 208.665 | 58.732 | 55.516 | 322.914 | 277.253 | 81.419 | 32.925 | 391.596 |
| *Remaining MSW landfilled* | *Mg/a* | *211.350* | *44.592* | *66.565* | *322.507* | *467.830* | *136.182* | *180.594* | *784.605* | *621.603* | *188.784* | *107.105* | *917.492* |
| ***Total Reduction of BD*** | ***Share*** | *0%* | *0%* | *0%* | **0%** | *0%* | *0%* | *0%* | **0%** | *0%* | *0%* | *0%* | **0%** |
| ***Costs:*** *- greenwaste* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Paper collect./treat.* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *MBT treatment* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Saved Landfill costs* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Total Reduction costs*** | ***T€/a*** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

| 2004 | | North-West | | year: | 2004 | North-Central | | year: | 2004 | North-East | | year: | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** |
| Population | Number | 184.532 | 117.385 | 210.676 | 512.593 | 547.916 | 242.500 | 375.390 | 1.165.806 | 475.727 | 347.187 | 462.889 | 1.285.803 |
| Originated MSW | Mg/a | 90.605 | 49.537 | 56.883 | 197.024 | 269.027 | 102.335 | 101.355 | 472.717 | 233.582 | 146.513 | 124.980 | 505.075 |
| Originated BD Waste | Mg/a | 40.412 | 21.364 | 17.486 | 79.263 | 119.994 | 44.135 | 31.157 | 195.286 | 104.184 | 63.188 | 38.420 | 205.792 |
| **"Green" waste coll.** | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Inhabitants | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Collected green waste | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Paper collection** | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Inhabitants | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Collected paper | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Biowaste collection** | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Inhabitants | Number | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Collected biowaste | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Reduction of BD | Mg/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Reduction by collection** | Mg/a | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Remaining BD in MSW | Mg/a | 40.412 | 21.364 | 17.486 | 79.263 | 119.994 | 44.135 | 31.157 | 195.286 | 104.184 | 63.188 | 38.420 | 205.792 |
| MBT-Treatment of MSW | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| MBT-Treatment of BD | Mg/a BD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *MBT-Treatment, MSW* | *Mg/a total* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| **Total Reduction of BD** | **Mg/a** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Remaining BD to landfill | Mg/a | 40.412 | 21.364 | 17.486 | 79.263 | 119.994 | 44.135 | 31.157 | 195.286 | 104.184 | 63.188 | 38.420 | 205.792 |
| *Remaining MSW landfilled* | *Mg/a* | *90.605* | *49.537* | *56.883* | *197.024* | *269.027* | *102.335* | *101.355* | *472.717* | *233.582* | *146.513* | *124.980* | *505.075* |
| ***Total Reduction of BD*** | ***Share*** | *0%* | *0%* | *0%* | **0%** | *0%* | *0%* | *0%* | **0%** | *0%* | *0%* | *0%* | **0%** |
| ***Costs:*** *- greenwaste* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Paper collect./treat.* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *MBT treatment* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Saved Landfill costs* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Total Reduction costs*** | ***T€/a*** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

## **Appendix B** *Region-wise concept components in 2010*

| 2010 | | North-West | | year: | 2010 | North-Central | | year: | 2010 | North-East | | year: | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** |
| Population | Number | 186.241 | 118.472 | 190.349 | 495.062 | 552.991 | 244.745 | 328.199 | 1.125.935 | 480.132 | 350.403 | 411.294 | 1.241.829 |
| Originated MSW | Mg/a | 91.444 | 49.995 | 51.394 | 192.834 | 271.518 | 103.283 | 88.614 | 463.415 | 235.745 | 147.870 | 111.049 | 494.664 |
| Originated BD Waste | Mg/a | 40.787 | 21.562 | 15.799 | 78.148 | 121.105 | 44.544 | 27.241 | 192.889 | 105.149 | 63.773 | 34.137 | 203.060 |
| **"Green" waste coll.** | Share | 70% | 70% | 0% | 43% | 70% | 70% | 0% | 50% | 70% | 70% | 0% | 47% |
| Inhabitants | Number | 130.368 | 82.931 | 0 | 213.299 | 387.093 | 171.322 | 0 | 558.415 | 336.093 | 245.282 | 0 | 581.375 |
| Collected green waste | Mg/a | 3.259 | 2.073 | 0 | 5.332 | 9.677 | 4.283 | 0 | 13.960 | 8.402 | 6.132 | 0 | 14.534 |
| **Paper collection** | Share | 50% | 50% | 0% | 31% | 50% | 50% | 0% | 35% | 50% | 50% | 0% | 33% |
| Inhabitants | Number | 93.120 | 59.236 | 0 | 152.357 | 276.495 | 122.373 | 0 | 398.868 | 240.066 | 175.201 | 0 | 415.268 |
| Collected paper | Mg/a | 2.328 | 1.481 | 0 | 3.809 | 6.912 | 3.059 | 0 | 9.972 | 6.002 | 4.380 | 0 | 10.382 |
| **Biowaste collection** | Share | 0% | 20% | 0% | 5% | 0% | 20% | 0% | 4% | 0% | 20% | 0% | 6% |
| Inhabitants | Number | 0 | 23.694 | 0 | 23.694 | 0 | 48.949 | 0 | 48.949 | 0 | 70.081 | 0 | 70.081 |
| Collected biowaste | Mg/a | 0 | 2.369 | 0 | 2.369 | 0 | 4.895 | 0 | 4.895 | 0 | 7.008 | 0 | 7.008 |
| Reduction of BD | Mg/a | 0 | 1.659 | 0 | 1.659 | 0 | 3.426 | 0 | 3.426 | 0 | 4.906 | 0 | 4.906 |
| **Reduction by collection** | Mg/a | **5.587** | **5.213** | **0** | **10.800** | **16.590** | **10.769** | **0** | **27.359** | **14.404** | **15.418** | **0** | **29.822** |
| Remaining BD in MSW | Mg/a | 35.199 | 16.349 | 15.799 | 67.348 | 104.515 | 33.775 | 27.241 | 165.531 | 90.745 | 48.356 | 34.137 | 173.238 |
| MBT-Treatment of MSW | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| MBT-Treatment of BD | Mg/a BD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *MBT-Treatment, MSW* | *Mg/a total* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| **Total Reduction of BD** | **Mg/a** | **5.587** | **5.213** | **0** | **10.800** | **16.590** | **10.769** | **0** | **27.359** | **14.404** | **15.418** | **0** | **29.822** |
| Remaining BD to landfill | Mg/a | 35.199 | 16.349 | 15.799 | 67.348 | 104.515 | 33.775 | 27.241 | 165.531 | 90.745 | 48.356 | 34.137 | 173.238 |
| *Remaining MSW landfilled* | *Mg/a* | *85.857* | *44.783* | *51.394* | *182.034* | *254.929* | *92.514* | *88.614* | *436.056* | *221.341* | *132.452* | *111.049* | *464.842* |
| ***Total Reduction of BD*** | ***Share*** | *14%* | *24%* | *0%* | **14%** | *14%* | *24%* | *0%* | **14%** | *14%* | *24%* | *0%* | **15%** |
| ***Costs:*** *- greenwaste* | *T€/a* | 65 | 41 | 0 | 107 | 194 | 86 | 0 | 279 | 168 | 123 | 0 | 291 |
| *Paper collect./treat.* | *T€/a* | 81 | 52 | 0 | 133 | 242 | 107 | 0 | 349 | 210 | 153 | 0 | 363 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 118 | 0 | 118 | 0 | 245 | 0 | 245 | 0 | 350 | 0 | 350 |
| *MBT treatment* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Saved Landfill costs* | *T€/a* | -56 | -52 | 0 | -108 | -166 | -108 | 0 | -274 | -144 | -154 | 0 | -298 |
| ***Total Reduction costs*** | ***T€/a*** | **91** | **160** | **0** | **250** | **270** | **330** | **0** | **599** | **234** | **472** | **0** | **706** |

| 2010 | | South-East | | year: | 2010 | South-Central | | year: | 2010 | South-West | | year: | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** |
| Population | Number | 434.435 | 106.647 | 214.804 | 755.886 | 961.634 | 325.694 | 590.557 | 1.877.884 | 1.277.718 | 451.498 | 308.656 | 2.037.873 |
| Originated MSW | Mg/a | 213.307 | 45.005 | 57.997 | 316.310 | 472.162 | 137.443 | 159.450 | 769.055 | 627.360 | 190.532 | 83.337 | 901.229 |
| Originated BD Waste | Mg/a | 95.141 | 19.410 | 17.829 | 132.380 | 210.598 | 59.276 | 49.016 | 318.890 | 279.820 | 82.173 | 25.618 | 387.611 |
| **"Green" waste coll.** | Share | 70% | 70% | 0% | 50% | 70% | 70% | 0% | 48% | 70% | 70% | 0% | 59% |
| Inhabitants | Number | 304.104 | 74.653 | 0 | 378.757 | 673.144 | 227.986 | 0 | 901.129 | 894.403 | 316.049 | 0 | 1.210.451 |
| Collected green waste | Mg/a | 7.603 | 1.866 | 0 | 9.469 | 16.829 | 5.700 | 0 | 22.528 | 22.360 | 7.901 | 0 | 30.261 |
| **Paper collection** | Share | 50% | 50% | 0% | 36% | 50% | 50% | 0% | 34% | 50% | 50% | 0% | 42% |
| Inhabitants | Number | 217.217 | 53.324 | 0 | 270.541 | 480.817 | 162.847 | 0 | 643.664 | 638.859 | 225.749 | 0 | 864.608 |
| Collected paper | Mg/a | 5.430 | 1.333 | 0 | 6.764 | 12.020 | 4.071 | 0 | 16.092 | 15.971 | 5.644 | 0 | 21.615 |
| **Biowaste collection** | Share | 0% | 20% | 0% | 3% | 0% | 20% | 0% | 3% | 0% | 20% | 0% | 4% |
| Inhabitants | Number | 0 | 21.329 | 0 | 21.329 | 0 | 65.139 | 0 | 65.139 | 0 | 90.300 | 0 | 90.300 |
| Collected biowaste | Mg/a | 0 | 2.133 | 0 | 2.133 | 0 | 6.514 | 0 | 6.514 | 0 | 9.030 | 0 | 9.030 |
| Reduction of BD | Mg/a | 0 | 1.493 | 0 | 1.493 | 0 | 4.560 | 0 | 4.560 | 0 | 6.321 | 0 | 6.321 |
| **Reduction by collection** | Mg/a | **13.033** | **4.692** | **0** | **17.726** | **28.849** | **14.331** | **0** | **43.180** | **38.332** | **19.866** | **0** | **58.197** |
| Remaining BD in MSW | Mg/a | 82.108 | 14.717 | 17.829 | 114.654 | 181.749 | 44.946 | 49.016 | 275.711 | 241.489 | 62.307 | 25.618 | 329.414 |
| MBT-Treatment of MSW | Share | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| MBT-Treatment of BD | Mg/a BD | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *MBT-Treatment, MSW* | *Mg/a total* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| **Total Reduction of BD** | **Mg/a** | **13.033** | **4.692** | **0** | **17.726** | **28.849** | **14.331** | **0** | **43.180** | **38.332** | **19.866** | **0** | **58.197** |
| Remaining BD to landfill | Mg/a | 82.108 | 14.717 | 17.829 | 114.654 | 181.749 | 44.946 | 49.016 | 275.711 | 241.489 | 62.307 | 25.618 | 329.414 |
| *Remaining MSW landfilled* | *Mg/a* | *200.274* | *40.313* | *57.997* | *298.584* | *443.313* | *123.112* | *159.450* | *725.876* | *589.028* | *170.666* | *83.337* | *843.032* |
| ***Total Reduction of BD*** | ***Share*** | *14%* | *24%* | *0%* | **13%** | *14%* | *24%* | *0%* | **14%** | *14%* | *24%* | *0%* | **15%** |
| ***Costs:*** *- greenwaste* | *T€/a* | 152 | 37 | 0 | 189 | 337 | 114 | 0 | 451 | 447 | 158 | 0 | 605 |
| *Paper collect./treat.* | *T€/a* | 190 | 47 | 0 | 237 | 421 | 142 | 0 | 563 | 559 | 198 | 0 | 757 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 107 | 0 | 107 | 0 | 326 | 0 | 326 | 0 | 451 | 0 | 451 |
| *MBT treatment* | *T€/a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Saved Landfill costs* | *T€/a* | -130 | -47 | 0 | -177 | -288 | -143 | 0 | -432 | -383 | -199 | 0 | -582 |
| ***Total Reduction costs*** | ***T€/a*** | **212** | **144** | **0** | **355** | **469** | **439** | **0** | **908** | **623** | **608** | **0** | **1.231** |

## **Appendix C** *Region-wise concept components in 2013*

| 2013 | | North-West | | year: 2013 | | North-Central | | year: 2013 | | North-East | | year: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** |
| Population | Number | 187.362 | 119.186 | 180.998 | 487.546 | 556.320 | 246.219 | 306.301 | 1.108.841 | 483.023 | 352.513 | 387.438 |
| Originated MSW | Mg/a | 91.995 | 50.296 | 48.869 | 191.161 | 273.153 | 103.904 | 82.701 | 459.759 | 237.164 | 148.760 | 104.608 |
| Originated BD Waste | Mg/a | 41.032 | 21.692 | 15.023 | 77.747 | 121.834 | 44.812 | 25.423 | 192.069 | 105.782 | 64.157 | 32.157 |
| **"Green" waste coll.** | Share | 80% | 80% | 0% | 50% | 80% | 80% | 0% | 58% | 80% | 80% | 0% |
| Inhabitants | Number | 149.890 | 95.349 | 0 | 245.238 | 445.056 | 196.975 | 0 | 642.032 | 386.419 | 282.010 | 0 |
| Collected green waste | Mg/a | 3.747 | 2.384 | 0 | 6.131 | 11.126 | 4.924 | 0 | 16.051 | 9.660 | 7.050 | 0 |
| **Paper collection** | Share | 65% | 65% | 0% | 41% | 65% | 65% | 0% | 47% | 65% | 65% | 0% |
| Inhabitants | Number | 121.785 | 77.471 | 0 | 199.256 | 361.608 | 160.042 | 0 | 521.651 | 313.965 | 229.133 | 0 |
| Collected paper | Mg/a | 3.045 | 1.937 | 0 | 4.981 | 9.040 | 4.001 | 0 | 13.041 | 7.849 | 5.728 | 0 |
| **Biowaste collection** | Share | 0% | 50% | 0% | 12% | 0% | 50% | 0% | 11% | 0% | 50% | 0% |
| Inhabitants | Number | 0 | 59.593 | 0 | 59.593 | 0 | 123.110 | 0 | 123.110 | 0 | 176.256 | 0 |
| Collected biowaste | Mg/a | 0 | 5.959 | 0 | 5.959 | 0 | 12.311 | 0 | 12.311 | 0 | 17.626 | 0 |
| Reduction of BD | Mg/a | 0 | 4.172 | 0 | 4.172 | 0 | 8.618 | 0 | 8.618 | 0 | 12.338 | 0 |
| **Reduction by collection** | Mg/a | **6.792** | **8.492** | **0** | **15.284** | **20.167** | **17.543** | **0** | **37.710** | **17.510** | **25.117** | **0** |
| Remaining BD in MSW | Mg/a | 34.240 | 13.200 | 15.023 | 62.463 | 101.668 | 27.269 | 25.423 | 154.359 | 88.273 | 39.041 | 32.157 |
| MBT-Treatment of MSW | Share | 0% | 0% | 0% | 0% | 15% | 0% | 0% | 10% | 0% | 0% | 0% |
| MBT-Treatment of BD | Mg/a BD | 0 | 0 | 0 | 0 | 15.250 | 0 | 0 | 15.250 | 0 | 0 | 0 |
| *MBT-Treatment, MSW* | *Mg/a total* | *0* | *0* | *0* | *0* | *37.948* | *0* | *0* | *37.948* | *0* | *0* | *0* |
| **Total Reduction of BD** | **Mg/a** | **6.792** | **8.492** | **0** | **15.284** | **35.417** | **17.543** | **0** | **52.960** | **17.510** | **25.117** | **0** |
| Remaining BD to landfill | Mg/a | 34.240 | 13.200 | 15.023 | 62.463 | 86.417 | 27.269 | 25.423 | 139.109 | 88.273 | 39.041 | 32.157 |
| *Remaining MSW landfilled* | *Mg/a* | *85.203* | *41.804* | *48.869* | *175.877* | *237.737* | *86.361* | *82.701* | *406.799* | *219.655* | *123.644* | *104.608* |
| ***Total Reduction of BD*** | ***Share*** | *17%* | *39%* | *0%* | **20%** | *29%* | *39%* | *0%* | **28%** | *17%* | *39%* | *0%* |
| ***Costs:*** *- greenwaste* | *T€/a* | 75 | 48 | 0 | 123 | 223 | 98 | 0 | 321 | 193 | 141 | 0 |
| *Paper collect./treat.* | *T€/a* | 107 | 68 | 0 | 174 | 316 | 140 | 0 | 456 | 275 | 200 | 0 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 298 | 0 | 298 | 0 | 616 | 0 | 616 | 0 | 881 | 0 |
| *MBT treatment* | *T€/a* | 0 | 0 | 0 | 0 | 1.897 | 0 | 0 | 1.897 | 0 | 0 | 0 |
| *Saved Landfill costs* | *T€/a* | -68 | -85 | 0 | -153 | -354 | -175 | 0 | -530 | -175 | -251 | 0 |
| ***Total Reduction costs*** | ***T€/a*** | **114** | **329** | **0** | **442** | **2.082** | **679** | **0** | **2.761** | **293** | **972** | **0** |

| 2013 | | South-East | | year: 2013 | | South-Central | | year: 2013 | | South-West | | year: 2013 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** |
| Population | Number | 437.051 | 107.289 | 200.070 | 744.410 | 967.424 | 327.655 | 554.294 | 1.849.373 | 1.285.412 | 454.217 | 267.304 | 2.006.932 |
| Originated MSW | Mg/a | 214.592 | 45.276 | 54.019 | 313.887 | 475.005 | 138.270 | 149.659 | 762.935 | 631.137 | 191.680 | 72.172 | 894.989 |
| Originated BD Waste | Mg/a | 95.714 | 19.527 | 16.606 | 131.847 | 211.866 | 59.633 | 46.006 | 317.505 | 281.505 | 82.668 | 22.186 | 386.359 |
| **"Green" waste coll.** | Share | 80% | 80% | 0% | 58% | 80% | 80% | 0% | 56% | 80% | 80% | 0% | 69% |
| Inhabitants | Number | 349.641 | 85.832 | 0 | 435.472 | 773.939 | 262.124 | 0 | 1.036.063 | 1.028.329 | 363.374 | 0 | 1.391.703 |
| Collected green waste | Mg/a | 8.741 | 2.146 | 0 | 10.887 | 19.348 | 6.553 | 0 | 25.902 | 25.708 | 9.084 | 0 | 34.793 |
| **Paper collection** | Share | 65% | 65% | 0% | 48% | 65% | 65% | 0% | 46% | 65% | 65% | 0% | 56% |
| Inhabitants | Number | 284.083 | 69.738 | 0 | 353.821 | 628.826 | 212.976 | 0 | 841.801 | 835.518 | 295.241 | 0 | 1.130.759 |
| Collected paper | Mg/a | 7.102 | 1.743 | 0 | 8.846 | 15.721 | 5.324 | 0 | 21.045 | 20.888 | 7.381 | 0 | 28.269 |
| **Biowaste collection** | Share | 0% | 50% | 0% | 7% | 0% | 50% | 0% | 9% | 0% | 50% | 0% | 11% |
| Inhabitants | Number | 0 | 53.645 | 0 | 53.645 | 0 | 163.828 | 0 | 163.828 | 0 | 227.109 | 0 | 227.109 |
| Collected biowaste | Mg/a | 0 | 5.364 | 0 | 5.364 | 0 | 16.383 | 0 | 16.383 | 0 | 22.711 | 0 | 22.711 |
| Reduction of BD | Mg/a | 0 | 3.755 | 0 | 3.755 | 0 | 11.468 | 0 | 11.468 | 0 | 15.898 | 0 | 15.898 |
| **Reduction by collection** | Mg/a | **15.843** | **7.644** | **0** | **23.487** | **35.069** | **23.345** | **0** | **58.415** | **46.596** | **32.363** | **0** | **78.959** |
| Remaining BD in MSW | Mg/a | 79.871 | 11.882 | 16.606 | 108.359 | 176.797 | 36.288 | 46.006 | 259.091 | 234.909 | 50.305 | 22.186 | 307.400 |
| MBT-Treatment of MSW | Share | 0% | 0% | 0% | 0% | 30% | 0% | 0% | 20% | 60% | 0% | 0% | 46% |
| MBT-Treatment of BD | Mg/a BD | 0 | 0 | 0 | 0 | 53.039 | 0 | 0 | 53.039 | 140.945 | 0 | 0 | 140.945 |
| *MBT-Treatment, MSW* | *Mg/a total* | *0* | *0* | *0* | *0* | *131.981* | *0* | *0* | *131.981* | *350.725* | *0* | *0* | *350.725* |
| **Total Reduction of BD** | **Mg/a** | **15.843** | **7.644** | **0** | **23.487** | **88.108** | **23.345** | **0** | **111.454** | **187.542** | **32.363** | **0** | **219.905** |
| Remaining BD to landfill | Mg/a | 79.871 | 11.882 | 16.606 | 108.359 | 123.758 | 36.288 | 46.006 | 206.052 | 93.964 | 50.305 | 22.186 | 166.454 |
| *Remaining MSW landfilled* | *Mg/a* | *198.749* | *37.632* | *54.019* | *290.399* | *386.897* | *114.925* | *149.659* | *651.481* | *443.596* | *159.317* | *72.172* | *675.084* |
| ***Total Reduction of BD*** | ***Share*** | *17%* | *39%* | *0%* | **18%** | *42%* | *39%* | *0%* | **35%** | *67%* | *39%* | *0%* | **57%** |
| ***Costs:*** *- greenwaste* | *T€/a* | 175 | 43 | 0 | 218 | 387 | 131 | 0 | 518 | 514 | 182 | 0 | 696 |
| *Paper collect./treat.* | *T€/a* | 249 | 61 | 0 | 310 | 550 | 186 | 0 | 737 | 731 | 258 | 0 | 989 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 268 | 0 | 268 | 0 | 819 | 0 | 819 | 0 | 1.136 | 0 | 1.136 |
| *MBT treatment* | *T€/a* | 0 | 0 | 0 | 0 | 6.599 | 0 | 0 | 6.599 | 17.536 | 0 | 0 | 17.536 |
| *Saved Landfill costs* | *T€/a* | -158 | -76 | 0 | -235 | -881 | -233 | 0 | -1.115 | -1.875 | -324 | 0 | -2.199 |
| ***Total Reduction costs*** | ***T€/a*** | **265** | **296** | **0** | **561** | **6.655** | **903** | **0** | **7.558** | **16.906** | **1.252** | **0** | **18.158** |

## **Appendix D** *Region-wise concept components in 2020*

| 2020 | | North-West | | year: | 2020 | North-Central | | year: | 2020 | North-East | | year: | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** |
| Population | Number | 224.196 | 91.994 | 166.350 | 482.540 | 586.944 | 240.838 | 269.673 | 1.097.455 | 611.076 | 250.740 | 348.600 | 1.210.416 |
| Originated MSW | Mg/a | 110.080 | 38.821 | 44.914 | 193.816 | 288.189 | 101.634 | 72.812 | 462.635 | 300.038 | 105.812 | 94.122 | 499.973 |
| Originated BD Waste | Mg/a | 49.099 | 16.743 | 13.807 | 79.649 | 128.541 | 43.833 | 22.383 | 194.756 | 133.826 | 45.635 | 28.934 | 208.394 |
| **"Green" waste coll.** | Share | 90% | 90% | 0% | 59% | 90% | 90% | 0% | 68% | 90% | 90% | 0% | 64% |
| Inhabitants | Number | 201.777 | 82.794 | 0 | 284.571 | 528.250 | 216.754 | 0 | 745.004 | 549.969 | 225.666 | 0 | 775.635 |
| Collected green waste | Mg/a | 5.044 | 2.070 | 0 | 7.114 | 13.206 | 5.419 | 0 | 18.625 | 13.749 | 5.642 | 0 | 19.391 |
| **Paper collection** | Share | 90% | 90% | 0% | 59% | 90% | 90% | 0% | 68% | 90% | 90% | 0% | 64% |
| Inhabitants | Number | 201.777 | 82.794 | 0 | 284.571 | 528.250 | 216.754 | 0 | 745.004 | 549.969 | 225.666 | 0 | 775.635 |
| Collected paper | Mg/a | 5.044 | 2.070 | 0 | 7.114 | 13.206 | 5.419 | 0 | 18.625 | 13.749 | 5.642 | 0 | 19.391 |
| **Biowaste collection** | Share | 0% | 80% | 0% | 15% | 0% | 80% | 0% | 18% | 0% | 80% | 0% | 17% |
| Inhabitants | Number | 0 | 73.595 | 0 | 73.595 | 0 | 192.671 | 0 | 192.671 | 0 | 200.592 | 0 | 200.592 |
| Collected biowaste | Mg/a | 0 | 7.359 | 0 | 7.359 | 0 | 19.267 | 0 | 19.267 | 0 | 20.059 | 0 | 20.059 |
| Reduction of BD | Mg/a | 0 | 5.152 | 0 | 5.152 | 0 | 13.487 | 0 | 13.487 | 0 | 14.041 | 0 | 14.041 |
| **Reduction by collection** | Mg/a | **10.089** | **9.291** | **0** | **19.380** | **26.412** | **24.325** | **0** | **50.737** | **27.498** | **25.325** | **0** | **52.823** |
| Remaining BD in MSW | Mg/a | 39.010 | 7.451 | 13.807 | 60.269 | 102.128 | 19.508 | 22.383 | 144.019 | 106.327 | 20.310 | 28.934 | 155.571 |
| MBT-Treatment of MSW | Share | 50% | 0% | 0% | 32% | 50% | 0% | 0% | 35% | 50% | 0% | 0% | 34% |
| MBT-Treatment of BD | Mg/a BD | 19.505 | 0 | 0 | 19.505 | 51.064 | 0 | 0 | 51.064 | 53.164 | 0 | 0 | 53.164 |
| *MBT-Treatment, MSW* | *Mg/a total* | *49.996* | *0* | *0* | *49.996* | *130.888* | *0* | *0* | *130.888* | *136.270* | *0* | *0* | *136.270* |
| **Total Reduction of BD** | **Mg/a** | **29.594** | **9.291** | **0** | **38.885** | **77.477** | **24.325** | **0** | **101.801** | **80.662** | **25.325** | **0** | **105.987** |
| Remaining BD to landfill | Mg/a | 19.505 | 7.451 | 13.807 | 40.764 | 51.064 | 19.508 | 22.383 | 92.955 | 53.164 | 20.310 | 28.934 | 102.407 |
| *Remaining MSW landfilled* | *Mg/a* | *80.486* | *29.530* | *44.914* | *154.931* | *210.713* | *77.309* | *72.812* | *360.834* | *219.376* | *80.488* | *94.122* | *393.986* |
| ***Total Reduction of BD*** | ***Share*** | *60%* | *55%* | *0%* | **49%** | *60%* | *55%* | *0%* | **52%** | *60%* | *55%* | *0%* | **51%** |
| ***Costs:*** *- greenwaste* | *T€/a* | 101 | 41 | 0 | 142 | 264 | 108 | 0 | 373 | 275 | 113 | 0 | 388 |
| *Paper collect./treat.* | *T€/a* | 177 | 72 | 0 | 249 | 462 | 190 | 0 | 652 | 481 | 197 | 0 | 679 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 368 | 0 | 368 | 0 | 963 | 0 | 963 | 0 | 1.003 | 0 | 1.003 |
| *MBT treatment* | *T€/a* | 2.500 | 0 | 0 | 2.500 | 6.544 | 0 | 0 | 6.544 | 6.813 | 0 | 0 | 6.813 |
| *Saved Landfill costs* | *T€/a* | -296 | -93 | 0 | -389 | -775 | -243 | 0 | -1.018 | -807 | -253 | 0 | -1.060 |
| ***Total Reduction costs*** | ***T€/a*** | **2.481** | **389** | **0** | **2.870** | **6.496** | **1.018** | **0** | **7.514** | **6.763** | **1.060** | **0** | **7.823** |

| 2020 | | South-East | | year: | 2020 | South-Central | | year: | 2020 | South-West | | year: | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **unit** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** | **Inner City** | **Suburbs** | **Rural** | **Total** |
| Population | Number | 398.108 | 163.354 | 175.305 | 736.766 | 947.167 | 388.647 | 494.569 | 1.830.383 | 1.272.292 | 522.054 | 191.979 | 1.986.325 |
| Originated MSW | Mg/a | 195.471 | 68.935 | 47.332 | 311.738 | 465.059 | 164.009 | 133.534 | 762.602 | 624.695 | 220.307 | 51.834 | 896.836 |
| Originated BD Waste | Mg/a | 87.186 | 29.730 | 14.550 | 131.466 | 207.430 | 70.734 | 41.049 | 319.213 | 278.632 | 95.014 | 15.934 | 389.580 |
| **"Green" waste coll.** | Share | 90% | 90% | 0% | 69% | 90% | 90% | 0% | 66% | 90% | 90% | 0% | 81% |
| Inhabitants | Number | 358.297 | 147.018 | 0 | 505.315 | 852.450 | 349.782 | 0 | 1.202.232 | 1.145.063 | 469.849 | 0 | 1.614.911 |
| Collected green waste | Mg/a | 8.957 | 3.675 | 0 | 12.633 | 21.311 | 8.745 | 0 | 30.056 | 28.627 | 11.746 | 0 | 40.373 |
| **Paper collection** | Share | 90% | 90% | 0% | 69% | 90% | 90% | 0% | 66% | 90% | 90% | 0% | 81% |
| Inhabitants | Number | 358.297 | 147.018 | 0 | 505.315 | 852.450 | 349.782 | 0 | 1.202.232 | 1.145.063 | 469.849 | 0 | 1.614.911 |
| Collected paper | Mg/a | 8.957 | 3.675 | 0 | 12.633 | 21.311 | 8.745 | 0 | 30.056 | 28.627 | 11.746 | 0 | 40.373 |
| **Biowaste collection** | Share | 0% | 80% | 0% | 18% | 0% | 80% | 0% | 17% | 0% | 80% | 0% | 21% |
| Inhabitants | Number | 0 | 130.683 | 0 | 130.683 | 0 | 310.918 | 0 | 310.918 | 0 | 417.643 | 0 | 417.643 |
| Collected biowaste | Mg/a | 0 | 13.068 | 0 | 13.068 | 0 | 31.092 | 0 | 31.092 | 0 | 41.764 | 0 | 41.764 |
| Reduction of BD | Mg/a | 0 | 9.148 | 0 | 9.148 | 0 | 21.764 | 0 | 21.764 | 0 | 29.235 | 0 | 29.235 |
| **Reduction by collection** | Mg/a | **17.915** | **16.499** | **0** | **34.414** | **42.623** | **39.253** | **0** | **81.876** | **57.253** | **52.727** | **0** | **109.981** |
| Remaining BD in MSW | Mg/a | 69.271 | 13.232 | 14.550 | 97.053 | 164.807 | 31.480 | 41.049 | 237.337 | 221.379 | 42.286 | 15.934 | 279.599 |
| MBT-Treatment of MSW | Share | 50% | 0% | 0% | 36% | 50% | 0% | 0% | 35% | 60% | 0% | 0% | 48% |
| MBT-Treatment of BD | Mg/a BD | 34.635 | 0 | 0 | 34.635 | 82.404 | 0 | 0 | 82.404 | 132.827 | 0 | 0 | 132.827 |
| *MBT-Treatment, MSW* | *Mg/a total* | *88.778* | *0* | *0* | *88.778* | *211.218* | *0* | *0* | *211.218* | *340.465* | *0* | *0* | *340.465* |
| **Total Reduction of BD** | **Mg/a** | **52.550** | **16.499** | **0** | **69.049** | **125.026** | **39.253** | **0** | **164.279** | **190.080** | **52.727** | **0** | **242.808** |
| Remaining BD to landfill | Mg/a | 34.635 | 13.232 | 14.550 | 62.417 | 82.404 | 31.480 | 41.049 | 154.933 | 88.552 | 42.286 | 15.934 | 146.772 |
| *Remaining MSW landfilled* | *Mg/a* | *142.921* | *52.437* | *47.332* | *242.689* | *340.033* | *124.756* | *133.534* | *598.322* | *434.615* | *167.579* | *51.834* | *654.029* |
| ***Total Reduction of BD*** | ***Share*** | *60%* | *55%* | *0%* | **53%** | *60%* | *55%* | *0%* | **51%** | *68%* | *55%* | *0%* | **62%** |
| ***Costs:*** *- greenwaste* | *T€/a* | 179 | 74 | 0 | 253 | 426 | 175 | 0 | 601 | 573 | 235 | 0 | 807 |
| *Paper collect./treat.* | *T€/a* | 314 | 129 | 0 | 442 | 746 | 306 | 0 | 1.052 | 1.002 | 411 | 0 | 1.413 |
| *Biowaste coll./treatm.* | *T€/a* | 0 | 653 | 0 | 653 | 0 | 1.555 | 0 | 1.555 | 0 | 2.088 | 0 | 2.088 |
| *MBT treatment* | *T€/a* | 4.439 | 0 | 0 | 4.439 | 10.561 | 0 | 0 | 10.561 | 17.023 | 0 | 0 | 17.023 |
| *Saved Landfill costs* | *T€/a* | -526 | -165 | 0 | -690 | -1.250 | -393 | 0 | -1.643 | -1.901 | -527 | 0 | -2.428 |
| ***Total Reduction costs*** | ***T€/a*** | **4.406** | **691** | **0** | **5.097** | **10.483** | **1.643** | **0** | **12.126** | **16.697** | **2.207** | **0** | **18.904** |