Mechanical Biological Treatment Plants

March 2010

JASPERS Solid Waste and Energy Division

Staff Working Papers

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Jonas Byström

March 2010 (Revised August 2010)

JASPERS Staff Working Papers are prepared by JASPERS experts with the aim of facilitating the discussions with counterparts in the context of their different assignments, mostly in terms of project scoping and applicable criteria and methodology. These papers normally originate as part of the assessment of a specific project, in which case the version published here is edited to be made non-project and non-country specific and therefore easily applicable to other projects in the sector. This particular paper deals with mechanical biological treatment plants (MBT), one of the options for treatment of residual waste.

Mechanical Biological Treatment Plants

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1 Introduction

The SWM system in many EU countries is currently being developed towards compliance with targets for materials recycling and biodegradable waste diversion contained in the Packaging Waste Directive (1994/62/EC)[1], Landfill Directive (1999/31/EC)[2] and in the new Waste Framework Directive (2008/98/EC)[3]. Together these directives and related targets will require cities and regions in many EU countries to make further efforts to boost recycling of materials and divert organic waste from landfills.

However, the available funds are limited, and authorities must ensure that funds are used in a cost-efficient way both with regard to technology selection and timing in relation to the target years.

While efforts are and will have to be made to divert increasing amounts of recyclable materials and bio-waste through separate collection and related treatment, and through home composting in rural areas, it is clear that to reach the challenging targets for diversion of biodegradable waste presented in the Landfill Directive, there will be a need also to target the residual waste stream.

One option available for residual waste treatment is *mechanical biological treatment* (MBT). This is a term given to residual waste treatment facilities combining some form of mechanical sorting/physical

1 Recycling targets to be achieved by end of 2013 are: glass: 60%, paper and cardboard: 60%, metal: 50%, plastic: 22.5%. The total recycling share: 55-80%, and recovery share: minimum 60%.

2 For countries that landfilled more than 80% biodegradable waste in 1995, disposal of biodegradable municipal waste to landfill must be reduced to 75% by 2010, 50% by 2013, and 35% by 2020 compared to the total generation in 1995.

3 Article 11 states that 50% of at least four material waste streams including paper, plastics, glass and metals originating from households and possibly other sources must be recycled by 2020.

treatment with biological treatment, possibly complemented with preparation of an energy rich waste fraction. While MBTs are applied in many European countries, there is such a wide variety of process designs that it is not straightforward to conclude if, to what extent and under what conditions MBTs can be applicable in a local context.

The objective of this Working paper is to provide information that can facilitate assessment of project proposals and give guidance in technology selection in relation to MBTs, and which can contribute to a structured and constructive dialogue between different stakeholders. The Note also introduces another option for residual waste treatment and alternatives for treatment of separately collected waste streams, however not on a detailed level, since this is outside the scope of this Note.

While efforts have been made to provide accurate and objective data and information, this Note can not replace detailed evaluations of project proposals on a specific county level, based on accurate data on e.g. current and predicted future waste generation and composition, and factoring in the local context. Where necessary, waste composition analyses should be carried out to provide a reliable decision basis.

2 Required waste management developments

The *Landfill Directive* prohibits disposal of un-treated waste and introduces targets for diversion of biodegradable waste from landfills. The diversion can to some extent be accomplished through separate bio-waste collection and related treatment in e.g. composting facilities, and by home composting in rural areas. However, such up-stream diversion activities must generally be complemented with treatment of bio-waste remaining in the residual waste stream.

The need for and timing of introduction of residual waste treatment depends on i) the 1995 organic waste generation benchmark, ii) the waste composition and iii) the long-term capture rate and efficiency of existing and planned separate bio-waste collection and home composting schemes.

Since separate bio-waste collection and home composting are not very widespread in many EU countries it can be difficult to determine how effective such systems could become in a specific setting, once further expanded and developed. When looking at international experience it is important to properly consider the differences in urban structure in the local context compared to some western European countries with successful bio-waste separate collection systems. For example, cities in the eastern parts of Europe often have a higher share of the population living in large apartment complexes than in cities in Western Europe. General experience shows that it can be difficult to establish effective bio-waste separate collection systems in large apartment complexes due to low participation rates, a poor quality of the collected waste, and potential adverse impact on environment and health from large containers with food waste. A huge effort is generally also required in terms of awareness-raising to promote separate collection in such areas. Therefore, high diversion rates achieved in some Western European cities, where a larger share of the population lives in single family houses, can not be achieved in all countries. While separate bio-waste collection and treatment and home composting are important up-stream measures, they must be complemented by residual waste treatment to meet relevant targets.

The *Packaging Directive* and new *Waste Framework Directive* introduce targets for recycling of packaging waste and household waste. Under the assumption that recyclables could be extracted from a mixed waste stream it could be argued that MBT is an alternative option to establishing separate collection systems for recyclable materials. However, experience tells *on one hand* that only a limited portion of the recyclables present in a mixed waste stream not subject to separate collection could be extracted in an MBT, and *on the other hand* that the quality of such recyclables would be of an inferior quality to recyclables collected in separate collection systems. From material recycling point of view, MBTs should therefore only be viewed as a complement to separate collection systems, aiming at retrieving recyclable materials remaining in the residual waste stream after separate collection. Since all EU countries have to meet demanding recycling targets for paper, glass, metal, plastic etc., upstream separate collection and recycling activities is an important first step that can be complemented, but not replaced by MBTs.

3 Waste treatment options

3.1 Separately collected waste streams

Separately collected recyclable materials need to be sorted/refined and prepared for transport in what is often referred to as a Material Recovery Facility (MRF). A MRF usually consists of a combination of mechanical sorting equipment and manual sorting for separation of the recyclable materials according to material type, colour etc.

Separately collected bio-waste streams can be treated in either aerobic or anaerobic treatment systems. In *aerobic treatment systems* the organic fraction is decomposed and partly mineralised in the presence of oxygen and under generation of heat. This process, often referred to as *composting*, can be carried out in trapezoidal elongated piles, referred to as *windrows*, or in some form of contained systems, e.g. tunnels, halls or drums, often referred to as *in-vessel* systems. While a basic windrow system is less expensive, the in-vessel system facilitates control of both the composting process and the volatile emissions/odours. Such systems are therefore appropriate for waste streams with odour generating components, or when the facility is located close to residential or other sensitive areas. An intermediate step between the open windrow and the in-vessel system are windrow systems with forced aeration and bio-filters, and possibly with semi-permeable membrane covers, which improves aeration of the windrow and allows some form of volatile emission/odour control. Windrow composting carried out in closed buildings also offers a possibility for volatile emission/odour control, albeit at an increased cost.

In *anaerobic treatment systems*, often referred to as *anaerobic digestion* (AD), the organic fraction is decomposed and partly mineralised in an oxygen-free environment, and under generation of methane (CH_4). The methane can be utilised to generate electricity and heat in e.g. gas engines. The output from the AD process, often referred to as *digestate*, can be utilised directly as a soil conditioner, but is often subject to composting in order to degrade organics that can not be degraded by anaerobic organisms and convert ammonia, which is phytotoxic, to nitrate ($NO_{3)}$. While anaerobic digestion offers the benefit of some energy recovery from the waste stream, and also is comparably less area demanding, it is a technically more complex and costly approach than aerobic treatment systems.

Both aerobic and anaerobic treatment of separately collected bio-waste has the potential to produce a high quality compost that generally can be used without restrictions.

The different options for treatment of separately collected waste streams outlined above must be evaluated and the most optimal selected in light of the amounts that realistically can be collected with due consideration given to national and EU targets. As a second step, different options for treatment of the residual waste stream remaining after separate collection should be identified and evaluated.

3.2 Residual waste streams

There are today two main options for treatment of residual waste; MBTs and thermal treatment such as waste incineration. Incineration is a well established and proven treatment option for residual waste in many countries, but usually is found more appropriate i) for larger cities/ agglomerations enabling facility economy of scale, ii) where the waste calorific value is such that spontaneous combustion can be ensured year round and that sufficient energy revenues can be secured to make the facility financially viable, iii) where there is a well developed district heating system or industrial facilities that can absorb the heat generated by the facility, and iv) where funding for the comparably high investment costs and related affordability of users can be ensured. Since such conditions are rarely found in many new EU member states, especially in small and medium sized cities, MBT is a relevant option to consider for residual waste treatment

4 Mechanical Biological Treatment

4.1 Configurations

Mechanical biological treatment (MBT) is a term used for residual waste treatment processes and facilities combining:

- *mechanical separation* of various waste streams and fractions, e.g. recyclable materials, biodegradable waste, high calorific waste and inert waste
- *biological treatment* of the biodegradable fraction.

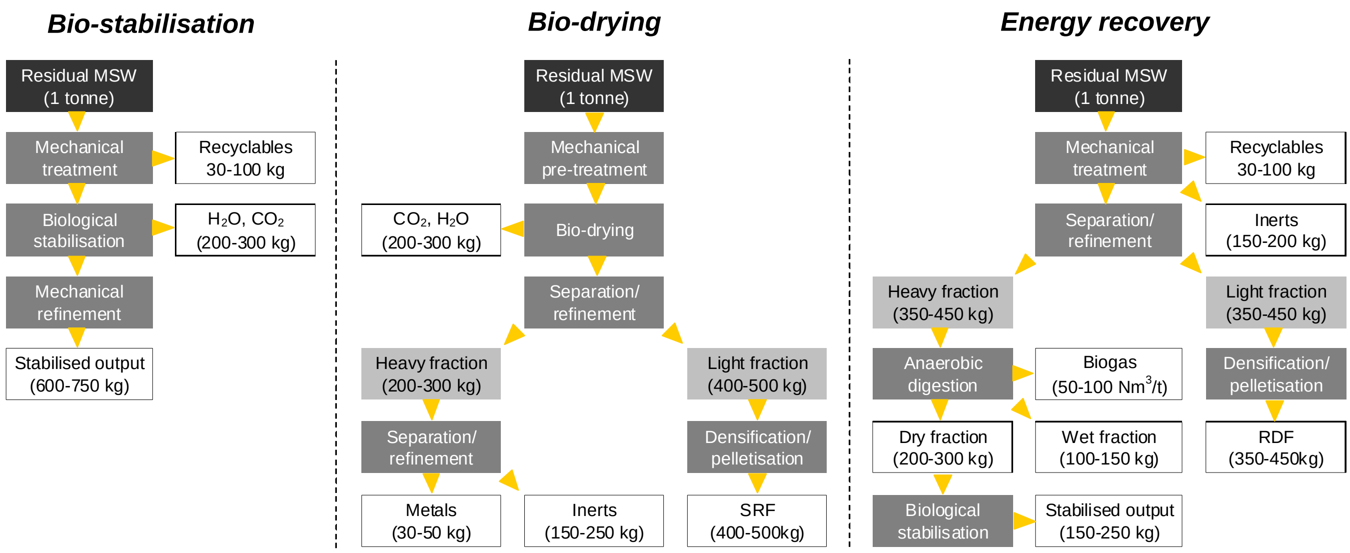
The different MBT processes and facilities in operation today vary with regard to:

- *mechanical separation/sorting processes*, ranging from simple screening to automatic sorting and separation of different waste fractions
- *biological treatment processes*, either *aerobic* (treatment in open windrows or in in-vessel systems), or *anaerobic* (treatment in digestion chambers)
- *outputs,* ranging from an inert fraction + a stabilised bio-waste in basic process configurations to recyclable materials, biogas, compost-like output (CLO) and refuse derived fuel (RDF) or solid recovered fuel (SRF) in more complex process configurations.

Considering these variations there are basically three main types of MBT configurations, which are optimised for:

1. *bio-stabilisation* - extraction of recyclable materials followed by aerobic bio-stabilisation of organic waste components before landfill disposal
2. *bio-drying* - production of a high calorific fraction (SRF) through short and intensive aerobic treatment of residual waste aimed at decreasing the moisture content but limit the biological degradation of the waste followed by mechanical sorting and extraction of recyclable and inert materials
3. *energy recovery* - extraction of recyclable materials, separation of a high calorific fraction (RDF) for off-site thermal utilisation and aerobic/anaerobic treatment of a biodegradable fraction which can be landfilled or if possible used beneficially in non-agricultural applications

These three MBT types represent a range from a very basic MBT aimed primarily at meeting Landfill Directive targets in a low cost manner, to a complex MBT including anaerobic digestion of the organic fraction aiming at recovery of materials and energy from waste. Typical material flows in these three alternative MBT configurations treating a residual municipal solid waste stream are presented below.



4.2 Outputs

Recyclables

Since MBT facilities target a residual waste stream, a share of the recyclable materials has been extracted through separate collection systems at an earlier stage. Nevertheless, many MBT configurations aim at extracting some recyclable material remaining in the residual waste stream, notably Fe and non-Fe metals, and sometimes also plastic, glass and cardboard. The quality of such materials is however inferior to those collected in separate collection systems. The amounts of recyclable materials extracted in MBT's depend on the level of up-stream separate collection of such materials, and on whether an energy rich RDF/SRF fraction is produced or not.

Stabilised bio-waste

In MBT configurations aiming at stabilising the biodegradable waste before landfill disposal, a combination of 4-8 weeks intensive degradation of organic contents and 8-12 weeks maturation is often applied. This will degrade/mineralise a large part of the organic content of the waste and hence decrease the negative impact from degrading organic waste in landfills in the form of emissions of methane rich landfill gas and generation of organics rich leachate. This will also reduce the volume of the treated waste up to 40% (30% in mass), and hence contribute to saving landfill space, and reduce the need for landfill gas and leachate management.

In its simplest form the biological treatment process is carried out in open windrows, which can be subject to forced aeration to promote degradation. If the facility is located close to residential areas and there is concern with odours generated from degrading food waste, the treatment can be carried out in contained systems, e.g. tunnels, drums or halls. This facilitates the control of the treatment process and of volatile emissions/odours through treatment of exhaust air.

Compost-like output

If a stabilised bio-waste is subject to sufficiently long maturation to stabilise the C:N ratio and reduce the levels of organic acids it can be further refined to produce a so called *compost-like output* (CLO). The refining step aims at removing visual contaminations such as plastic and glass and producing a homogenous product.

Whereas removing waste residues often can be done to an acceptable degree, it is very difficult to remove other contaminants such as heavy metals resulting from treating a mixed rather than separately collected organic waste stream. This restricts the use of CLO to applications such as landfill cover or for rehabilitation of abandoned mines or contaminated land.

RDF/SRF

There are basically two types of energy rich outputs produced at MBT facilities:

- separated paper, plastics, wood and some textiles etc, often referred to as *refuse derived fuel* (RDF), which has a calorific value often ranging between 12-16 MJ/kg
- residual waste dried through a quick aerobic treatment (bio-drying), from which low calorific value components and inert waste has been separated, often referred to as *solid recovered fuel* (SRF), which has a calorific value often ranging between 14-18 MJ/kg

To some extent the calorific value of the RDF/SRF depends on the calorific value of the input waste stream. This will in turn depend on i) the original waste composition, where waste in affluent countries tend to have higher calorific value due to higher shares of packaging waste and lower shares of food waste, and ii) the level of separate collection, where bio-waste, glass and metal separate collection increases the calorific value of residual waste, while paper and plastic separate collection decreases the calorific value of residual waste. The RDF/SRF produced can be utilised as a partially renewable fuel in cement kilns or power plants. Depending on the off-taker there might be a need to refine the RDF with regard to particle size, metal content, chlorine content etc. which can require an additional refinement step of the RDF/SRF.

Biogas

In MBT facilities employing anaerobic treatment of the biodegradable fraction in digestion chambers, an energy rich biogas is produced. The biogas can be utilised for generation of electricity and heat in e.g. gas engines.

4.3 Emissions

Since a MBT facility handles and treats a waste stream containing kitchen waste there is always a need to consider and manage volatile emissions/odours generated in the different processes. Location at sufficient distances from inhabited areas is a first and important measure.

The emissions from open windrow treatment facilities are difficult to control and require attention to the operation. Such facilities are therefore generally not advisable if the site is located close to residential areas. The emission and odour generated from enclosed treatment systems, such as tunnel or drum systems, is easier to control but such treatment systems are more expensive.

Emissions from enclosed treatment facilities can be treated in bio-filters consisting of e.g. compost or wood chips in which organic compounds are degraded by micro-organisms under moist and temperate conditions. In Germany and Austria emission standards are so strict that other treatment methods, often regenerative thermal oxidisers (RTO), must be applied. While such systems are very effective, the investment and operation costs are also quite high.

4.4 Cost levels

The investment costs for MBT facilities vary depending on size, configuration and local factors. The operation and maintenance (O&M) costs vary according to configuration and related level of complexity of the facility. The specific investment costs vary also with the size of the facility, which often ranges between 10,000 t/year up to 300,000 t/year. However, the economy of scale is not that apparent in MBT facilities with capacity above 100,000 t/year.

An indication of the specific investment and O&M cost ranges and total treatment costs in relation to the input capacity for the three MBT facility types discussed above, and some other waste treatment facility types for comparison, are given in the table below.

Type	Investment cost (€/t/yr)	O&M cost (€/t)	Total cost (€/t)
Separately collected waste streams			
Windrow composting	50 – 200	10 - 20	15 - 30
In-vessel composting	150 – 300	15 - 30	30 - 60
Anaerobic digestion	200 – 400	25 - 50	50 - 90
Residual waste streams			
MBT - bio-stabilisation	100 – 200	10 - 25	20 - 40[1]
MBT - Bio-drying	200 – 350	20 - 35	40 - 70[1]
MBT - Energy recovery	250 – 450	25 - 45	60 - 90[1]
Waste incineration	500 – 900	25 – 45	100 - 200[2]

[1] Excluding handling costs for RDF/SRF [2] Excluding revenues from energy sale

4.5 Permitting

SEA Directive

MBT facilities usually result from a plan or programme such as a National/Regional/County Waste Management Plan, for which SEA procedure and related public consultation was undertaken was undertaken according to Directive 2001/42/EC. Certain MBT facilities might require a land development plan, where provisions of Article 3(5) of the SEA Directive is relevant.

EIA Directive

MBT facilities would be considered Annex II (point 11.b) facilities under the EIA Directive (85/337/EC), as subsequently modified. According to the EIA screening phase's decision (Article 4.2), certain MBT facilities would require an EIA and related public consultation.

The competency for coordinating EIA procedures for a MBT facility rests with the Environmental Protection Agency (local or regional), which often coordinates the stages of the EIA procedure (i.e. screening, scoping and reviewing of the EIA Report). When the EIA is completed, the competent authority issues the Environmental Agreement, which often represents the administrative document issued by the environmental protection competent authority, in order to establish the conditions and measures, as applicable, regarding protection of environment that shall be respected, if a decision is taken to proceed with the project.

In addition to the Environmental Agreement, a Development Consent must be issued for the MBT facility. This is the decision by the competent authority which entitles the developer to proceed with the project.

IPPC Directive

MBT facilities with a capacity exceeding 50 tonnes/day would require an integrated environmental permit in accordance with the IPPC Directive 2008/1/EC (point 5.3 of Annex I).

With respect to compliance with IPPC Directive, the design of MBT facilities should consider the BREF on *Waste Treatments Industries* as well as horizontal BREF(s), in particular the BREFs on *Monitoring, Economics* and *Cross-Media Effects*.

4.6 International experience

Developments of MBT technologies and concepts started in Germany following bans on landfilling untreated waste introduced in 1993 in the Technical Directive for Sanitary Landfills, which had a transition period until 2005. A similar ban was introduced in Austria with a deadline in 2004. Opposition towards waste incineration boosted these developments. Today, there are about 60 MBT facilities in Germany and 15 in Austria. More recently a number of MBT facilities have been built also in Italy and Spain, two countries which now are believed to have the largest MBT capacities in Europe. In UK there are a few facilities in operation, and there are plans to implement additional so that approximately 15 will be operational by 2010.

4.7 Advantages and disadvantages

While MBT can be an appropriate solution for residual waste treatment, and as such has some advantages, there are also some disadvantages that must be considered in planning or evaluating an MBT facility, as elaborated in the table below:

Advantages of MBT	Disadvantages of MBT
A comparably low-cost alternative for treating residual waste to reach compliance with relevant targets	Only a pre-treatment method requiring handling/disposal of outputs and residues
Reduces volume and biodegradability of organic waste and related costs and adverse impacts at landfills	Limited/restricted markets for potential outputs
Extracts some recyclable materials, primarily metals, remaining in the residual waste stream	Potentially additional high costs for handling of outputs
Option to generate energy rich fuel fraction that can replace fossil fuel in energy production	Quite high area requirements, especially for aerobic treatment type MBTs
Option to generate both electricity and heat from biogas produced in anaerobic digestion	Only limited reduction in mass/volume of waste outputs to be landfilled
Some flexibility to changes in the waste stream	Difficult to reduce/handle volatile emissions/odours
Some decontamination of waste in the separation step	
Comparably easy to secure public acceptance	

5 MBT evaluation parameters

The MBT configurations marketed today have different advantages and disadvantages that must be properly considered when selecting a suitable MBT configuration in a local context. Key parameters that can influence the feasibility and viability in this regard are discussed in the following sections.

5.1 Target compliance

Since MBTs primarily are applied as a measure to meet the Landfill directive targets their level of treatment of organic waste components is a key parameter. While all MBT facilities include some form of biological treatment, the level of stabilisation of the organic waste varies with the technology applied and the treatment time.

While there are no EU regulations or guidelines in force that prescribes the required level of stabilisation of organic waste in a MBT facility, the Second Draft of the Bio-waste Directive issued in 2001 gives an indication through the following statement on MBT stabilised waste: “If residual municipal waste undergoes a mechanical/biological treatment prior to landfilling, the achievement of either a Respiration Activity after four days (AT_4) below 10 mg O_2/g dm or a Dynamic Respiration Index below 1,000 mg O_2/kg VS/h shall deem that the treated residual municipal waste is not any more biodegradable waste in the meaning of Article 2 (m) of Directive 1999/31/EC.” The Austrian and German landfill ordinances specify that biodegradable waste must reach levels of stabilisation of respectively 7 and 5 mg O_2/g dm before landfill disposal.

The configuration and type of biological treatment in a MBT facility will in many cases depend on whether national requirements exist for the quality of stabilised waste that can be landfilled. In countries such as Germany and Austria, in-vessel biological treatment systems are generally applied to reach the levels of stabilisation required[4]. In other countries simpler biological treatment methods, such as windrows might suffice.

5.2 Target year of introduction

An aspect related to the target compliance is the landfill directive target year (2010, 2013 or 2020) by which separate bio-waste collection and home composting systems must be complemented with facilities for treatment of residual waste. With the relevant targets for recycling and diversion of biodegradable waste given, this will depend on i) the 1995 organic waste generation benchmark, ii) the waste composition, and iii) the predicted efficiency of existing and planned separate collection

[4] There are indications that the German target can be reached in a combination of 4 weeks well operated in-vessel composting, followed by 4-6 weeks maturation.

systems for recyclable materials and bio-degradable waste and efficiency of home composting systems, something which need to be evaluated in detail on an individual project level.

5.3 Markets for MBT outputs

Whereas in theory MBT facilities could be expected to produce outputs that generate revenue streams, reality is different. While some of the recyclables and the energy generated from anaerobic AD biogas often can generate revenues, the latter albeit at a comparably high cost, the main MBT output streams (stabilised bio-waste and RDF/SRF) often need to be handled or disposed at a cost. The availability of markets for different outputs, and related costs or revenues for handling these, should therefore be considered carefully before deciding on the MBT option and a specific process layout.

Stabilised bio-waste

Many MBT facilities are configured to stabilise the organic waste components before landfilling. However, there is a cost associated also with landfilling on an EU compliant landfill. It is therefore advisable to aim at using the stabilised bio-waste in beneficial ways to the extent possible and allowed. There are no direct EU guidelines on this issue, but in the Working Document Biological Treatment of Biowaste, 2nd draft, 2001, it is stated that if the stabilised bio-waste meets certain criteria and if authorised in a member state, it can be used as a component in artificial soils for landfill cover, landscape restoration in old mines, anti-noise barriers, road construction, golf courses, ski slopes, football fields and similar non-agricultural applications. However, the application shall not exceed 200 t/ha and shall not be repeated for at least 10 years.

Compost-like output

High heavy metal contents in compost-like output (CLO) often results in difficulties getting the product approved for use as compost by authorities and accepted by the market, and thereby often limit CLO use to e.g. landfill covers, remediation and landscaping applications. Efforts to separately collect household hazardous waste like batteries would contribute to reducing the heavy metal content of the CLO, but not to an extent that the output from mixed waste streams could be used for compost applications.

When marketing CLO it must also be considered that the Animal By-products Regulation (2002/1774) specifies that for composting and anaerobic digestion of Category 3 material, i.e. non-risk material such as kitchen and food waste, it must be reduced to max 12 mm, and be treated at a minimum temperature of 70^{o}C for at least 60 minutes, which is not always achieved in MBT technologies/plants.

RDF/SRF

The costs that have to be paid to off-takers of RDF/SRF vary depending on the quality and demand. During recent years the supply has exceeded the demand forcing MBT operators to pay relatively high gate fees. However, with an increasing demand following increasing interest from cement kilns and power plants to replace fossil fuels, and new investments in RDF fired WtE facilities treatment costs are decreasing. In addition to gate fees, the costs of transports to off-takers need to be factored in when assessing the viability of a RDF/SRF proposal.

Since the cost of handling/treatment of RDF can have a significant impact on the overall financial viability of a MBT facility, it is important to properly assess the total treatment costs. A long-term off-take agreement can reduce risks in this regard.

Heat/electricity

In MBT configurations with anaerobic digestion, the generated biogas can be utilised to generate electricity in e.g. gas engines, and the spill heat can be recovered. As indicated in Section 4.2, some of the electricity and heat produced will generally be consumed in the process, but some electricity can be sold to the grid. The potential revenues from sale of electricity as well as the comparably high costs must be considered when assessing the financial viability of an anaerobic digestion based MBT facility. In order to recover the co-generated heat, potential users have to be located very close to the facility. This often results in that heat can only be used to cover in-house demands.

5.4 Technical complexity

Of the three main types of MBTs discussed above, the level of complexity regarding operation and maintenance is somewhat related to the investment cost, in that a basic low-cost bio-stabilisation facility is comparably simpler to operate and maintain than for example an MBT that produces RDF and employs anaerobic digestion.

5.5 Energy policies

In countries/regions where renewable energy production is high on the agenda, and where subsidies favour production of renewable energy, MBTs with the production of RDF/SRF and/or biogas from anaerobic digestion could compare favourably to other options.

5.6 Land availability

In cases where only limited land is available, and where the site is located close to inhabited areas, the lower land-take of an anaerobic digestion facility compared to a facility employing aerobic treatment is a factor to consider.

5.7 Cost level and affordability

Needless to say, the investment and operation and maintenance (O&M) cost of different MBT options is a key factor to consider when selecting among different MBT options, and as indicated in Section 4.4, the MBT costs vary significantly with their level of complexity. It should also be properly acknowledged that while grant support can be available for investment costs, there is generally a need to cover O&M costs through tariffs and user charges.

The cost level and affordability of MBT as a treatment option for residual waste should also be assessed in comparison to cost levels for separate collection and related treatment, in cases where it is considered to extend such systems beyond what is required to reach recycling target compliance.

Considering possible grants, the affordability of user charges in different MBT scenarios will be a key issue to consider when selecting MBT option or assessing a MBT proposal.

6 Applicability of different MBT configurations

A MBT facility should be considered as a complement rather than alternative to separate collection of recyclable materials/bio-waste and home composting. Hence it should be planned and applied for a residual waste stream after diversion of as large a share of recyclable materials and bio-waste as is technically and economically feasible.

MBTs employing aerobic treatment offer some flexibility in cases where the amount of separately collected bio-waste increases beyond expectations, since both windrow and in-vessel facilities can be converted from treating an organic waste stream separated from the residual waste in an MBT to treatment of separately collected bio-waste producing high quality compost.

When looking at the different MBT selection parameters discussed above, it could be argued that where there are no specific energy policies that would support MBTs with anaerobic digestion, and in cases where the land area available will be sufficient to allow construction also of the comparably more area demanding aerobic treatment type MBTs, the following parameters will be of primary relevance when assessing the appropriateness of MBT options: i) compliance with directives and regulations, ii) the markets for MBT outputs, iii) technical complexity, and iv) the cost level and related affordability.

Whether it is justified to complement the basic configuration with steps for extraction and preparation of RDF will basically depend on the presence of off-takers for such a product and related handling costs in comparison to landfilling also this part of the treated waste. It should be pointed out that the market and demand for RDF is dynamic, and it is therefore not possible to draw a general conclusion without studying the actual regional market conditions at a specific time.

A related issue to consider is whether it is necessary to landfill all stabilised bio-waste, or whether there are options to use this MBT output as a material for landfill covers, or as an input to artificial soils for non-agricultural purposes, as discussed earlier in Section 5.3. To minimise the landfilled amounts and related costs, efforts should be made to find alternative uses for the stabilised residual waste, to the extent allowed under national legislation.

Detailed waste generation and waste composition analyses, and assumptions of potential efficiency of separate collection systems and home composting in a project specific context in relation to the targets in 2010, 2013 and 2020 would yield information on which year MBTs would be required.

7 Checklist for MBT project proposals

Considering the complexity of MBT facilities, and the need to also take into account up-stream measures, there are many factors to consider when evaluating and assessing a MBT project proposal, the most relevant of which are listed below.

Checklist point	Issues that must be described/verified
Target year of commissioning	The target year of commissioning should match the 2013 or 2020 landfill directive target considering predicted separate collection efficiency and resulting waste flow
Coverage of separate collection	Should at least cover i) recyclable materials and ii) bio-waste from individual houses, markets, restaurants and hotels, and similar sources
Efficiency of separate collection	The total future diversion of recyclable materials and bio-waste via separate collection should generally be in the range of 25-50% of total MSW generation
MBT configuration	Description of treatment steps, technologies/processes, mass flows
Bio-waste stabilisation	Should encompass at least 4 weeks intensive treatment and 8 weeks maturation
Recycling output	Usually do not reach more than 10% of the input
Expected outputs	Described with regard to amount, characteristics and final destination/use/off-taker. For CLO and RDF/SRF some form of market study or preliminary off-take agreements should be presented and treatment/transport costs should be included
Expected residues	Type of residue, share of input, destination and related costs should be presented
Energy and water balance	The energy and water balances for the MBT facility should be presented
Distance to residents	Should be sufficient to avoid odour nuisance
Emissions and odour management	Exhaust air from contained facilities should be treated properly, e.g. in bio-filter. More advanced options such as RTO are difficult to justify
Permitting status	Permitting status should be presented (e.g. planning, EIA, IPPC decisions/permits)
Affordability	Proposed total SWM user tariff/user charge should not exceed 1.5% of average disposable income

8 Summary and conclusions

In summary it can be concluded that i) there is a future need for treatment of residual waste in many EU countries to meet landfill directive targets and ii) MBT can be an appropriate option for residual waste treatment.

MBT facilities reduce the amount of waste that needs to be landfilled and stabilise its biological components. In a basic configuration, the main output of a MBT facility is stabilised bio-waste while other potential outputs include:

- limited amounts of recyclable materials, of lower quality than from separate collection systems
- compost like output, of a lower quality than from separately collected bio-waste
- high calorific fractions (refuse derived fuel/solid recovered fuel)
- biogas

Availability of markets for different MBT outputs must be adequately considered by decision makers when taking decisions on MBT configuration.

A MBT facility should be considered as a complement rather than alternative to separate collection of recyclable materials/bio-waste. Hence it should be planned and applied for a residual waste stream after diversion of as large a share of recyclable materials and bio-waste as is technically and economically feasible.

In the analysis and planning of MBT as an option for residual waste treatment to meet upcoming targets for recycling and diversion of biodegradable waste there is a need to:

i. estimate the long-term capture rate and efficiency of separate material and bio-waste collection systems and home composting based on detailed waste generation and waste composition analyses and predictions, and by assessing data from pilot tests or international experience
ii. determine whether MBT facilities for residual waste treatment will be required to meet the Landfill directive targets in 2013 or 2020
iii. identify the most appropriate MBT configuration for treating the residual waste stream in order to meet relevant targets considering the markets for different types of outputs.

Important factors to consider in the assessment of different MBT configurations are:

- level of target compliance
- markets for MBT outputs
- technical complexity
- cost level and affordability

To the extent possible and allowed efforts should be made to find other uses for the stabilised biodegradable waste than disposal on landfill, e.g. as input to artificial soils used for e.g. landfill covers and rehabilitation of contaminated land or old mines.