

Technology Fact Sheet

Mechanical-biological treatment (MBT)ⁱ

1) Introduction

A mechanical biological treatment system is a waste processing facility that combines a waste sorting facility with biological treatment methods e.g. anaerobic digestion and/or composting. MBT plants are designed to process mixed household waste as well as commercial and industrial waste. Therefore, MBT is neither a single technology nor a complete solution, since it combines a wide range of techniques and processing operations (mechanical and biological) dictated by the market needs of the end products. Thus, MBT systems vary greatly in their complexity and functionality.

The products of the Mechanical Biological Treatment technology are:

- Recyclable materials such as metals, paper, plastics, glass etc.
- Unusable materials (inert materials) safely disposed to sanitary landfill
- Biogas (anaerobic digestion)
- Organic stabilized end product
- refuse derived fuel - RDF (High calorific fraction).

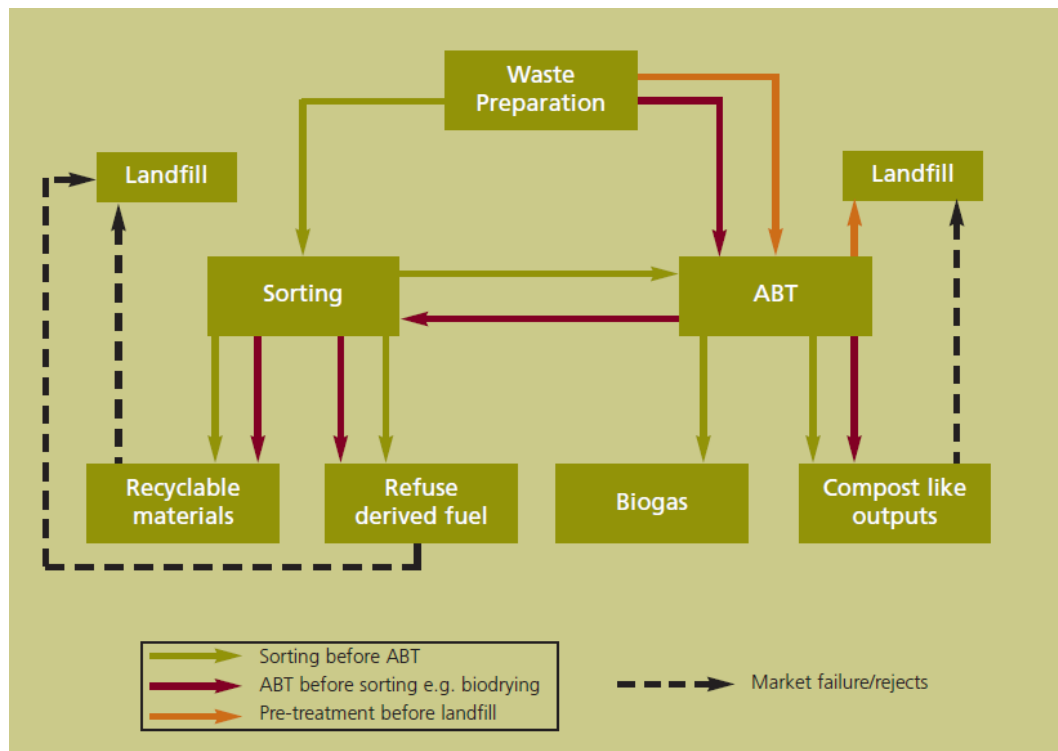
MBT systems can form an integral part of a region's waste treatment infrastructure. These systems are typically integrated with curb side collection schemes. In the event that a derivate fuel is produced as a by-product then a combustion facility would be required. Alternatively MBT practices can diminish the need for home separation and curb side collection of recyclable elements of waste. This gives the ability of local authorities and councils to reduce the use of waste vehicles on the roads and keep recycling rates high (DEFRA, 2007).

A key advantage of MBT is that it can be configured to achieve several different aims. Some typical aims of MBT plants include the:

- Pre-treatment of waste going to landfill;
- Diversion of non-biodegradable and biodegradable MSW going to landfill through the mechanical sorting of MSW into materials for recycling and/or energy recovery as refuse derived fuel (RDF);
- Diversion of biodegradable MSW going to landfill by:
 - Reducing the dry mass of organic waste prior to landfill;
 - Reducing the biodegradability of organic waste prior to landfill;
- Stabilisation into a compost-like output for use on land;
- Conversion into a combustible biogas for energy recovery; and/or
- Drying materials to produce a high calorific organic rich fraction for use as RDF

MBT plants may be configured in a variety of ways to achieve the required recycling, recovery and biodegradable municipal waste (BMW) diversion performance. Figure 1 illustrates configurations for MBT and highlights the components within each.

Figure 1 An illustration of the potential mechanical biological treatment options



(Source: DEFRA, 2007)

2) Technical requirements

A) Waste Preparation

MSW requires preparation before biological treatment or sorting of materials can be achieved. Initial waste preparation may take the form of simple removal of contrary objects, such as mattresses, carpets or other bulky wastes, which could cause problems with processing equipment downstream. Further mechanical waste preparation techniques may be used which aim to prepare the materials for subsequent separation stages. The objective of these techniques may be to split open refuse bags, thereby liberating the materials inside; or to shred and homogenise the waste into smaller particle sizes suitable for a variety of separation processes, or subsequent biological treatment depending on the MBT process employed (DEFRA, 2007).

Table 1 Waste preparation techniques

Ref	Technique	Principle	Key Concerns
A	Hammer Mill	Material significantly reduced in size by swinging steel hammers	Wear on Hammers, pulverising and 'loss' of glass / aggregates, exclusion of pressurised containers
B	Shredder	Rotating knives or hooks rotate at a slow speed with high torque. The shearing action tears or cuts most materials	Large, strong objects can physically damage, exclusion of pressurised containers
C	Rotating Drum	Material is lifted up the sides of a rotating drum and then dropped back into the centre. Uses gravity to tumble, mix, and homogenize the wastes. Dense, abrasive items such as glass or metal will help break down the softer materials, resulting in considerable size reduction of paper and other biodegradable materials	Gentle action – high moisture of feedstock can be a problem
D	Ball Mill	Rotating drum using heavy balls to break up or pulverise the waste	Wear on balls, pulverising and 'loss' of glass / aggregates
E	Wet Rotating Drum with Knives	Waste is wetted, forming heavy lumps which break against the knives when tumbled in the drum	Relatively low size reduction. Potential for damage from large contraries
F	Bag Splitter	A more gentle shredder used to split plastic bags whilst leaving the majority of the waste intact	Not size reduction, may be damaged by large strong objects

(Source: DEFRA, 2007)

B) Waste Separation

A common aspect of many MBT plant used for MSW management in the sorting of mixed waste into different fractions using mechanical means. The sorting of material may be achieved before or after biological treatment. No sorting is required if the objective of the MBT process is to pre-treat all the residual MSW to produce a stabilised output for disposal to landfill. Sorting the waste allows an MBT process to separate different materials which are suitable for different end uses. Potential end uses include material recycling, biological treatment, energy recovery through the production of RDF, and landfill. A variety of different techniques can be employed, and most MBT facilities use a series of several different techniques in combination to achieve specific end use requirements for different materials. Separation technologies exploit varying properties of the different materials in the waste. These properties include the size and shape of different objects, their density, weight, magnetism, and electrical (DEFRA, 2007).

Table 2 Waste separation techniques

	Separation Technique	Separation Property	Materials targeted	Key Concerns
1	Trommels and Screens	Size	Oversize – paper, plastic Small – organics, glass, fines	Air containment and cleaning
2	Manual Separation	Visual examination	Plastics, contaminants, oversize	Ethics of role, Health & Safety issues
3	Magnetic Separation	Magnetic Properties	Ferrous metals	Proven technique
4	Eddy Current Separation	Electrical Conductivity	Non ferrous metals	Proven technique
5	Wet Separation Technology	Differential Densities	Floats - Plastics, organics Sinks - stones, glass	Produces wet waste streams
6	Air Classification	Weight	Light – plastics, paper Heavy – stones, glass	Air cleaning
7	Ballistic Separation	Density and Elasticity	Light – plastics, paper Heavy – stones, glass	Rates of throughput
8	Optical Separation	Diffraction	Specific plastic polymers	Rates of throughput

(Source: DEFRA, 2007)

C) Biological Treatment

The biological element of an MBT process can take place prior to or after mechanical sorting of the waste. In some processes all the residual MSW is biologically treated to produce a stabilised output for disposal to landfill and no sorting is required. The biological processes used are either:

- Aerobic Bio-drying
- Aerobic In-vessel composting
- Anaerobic digestion

There are a variety of different biological treatment techniques which are used in MBT plant. Table 3 below outlines the key categories of biological treatment (DEFRA, 2007).

Table 3 Biological treatment options

Options	Biological Treatment
I	Aerobic - Bio-drying / Biostabilisation: partial composting of the (usually) whole waste
II	Aerobic - In-Vessel Composting: may be used to either biostabilise the waste or process a segregated organic rich fraction
III	Anaerobic Digestion: used to process an segregated organic rich fraction

(Source: DEFRA, 2007)

3) Status of the technology and its future market potential

The concept of MBT originated in Germany where it is an established waste treatment method. Regulatory restrictions on landfill space, the search for alternatives to incineration and increased costs of landfill disposal have been the major drivers for the development of these technologies. The largest European markets for established MBT plant include Germany, Austria, Italy, Switzerland and the Netherlands, with others such as the UK growing fast. Furthermore, other countries outside Europe are also using this technology.

Since the early 1990s, MBT processes have changed significantly, so today, numerous configurations of plant have developed, and these are provided by a variety of companies. There are over 70 MBT facilities in operation in Europe, with over 40 MBT facilities operating in Germany.

The Mechanical-Biological-Treatment (MBT) methodologies are more compatible with the demanding management requirements coming into effect in the E.U. and this explains the recent significant impetus on their development and use. By 2005, 80 plants with capacities ranging from 20.000 to 480.000 t/y and a cumulative capacity of 8.500.000 t/y had been constructed by 27 companies. By 2006, 123 plants are expected to be operating with an installed capacity of 13.000.000 t/y.

Most of these plants (and the largest) use Mechanical treatment and aerobic composting, followed by plants with mechanical treatment and anaerobic digestion and by a limited number of plants with aerobic drying followed by mechanical separation. The latter is only a pretreatment of MSW yielding a Solid Recovered Fuel (SRF).

Among the MBT alternatives, the mechanical treatment and aerobic composting is by far the most proven and economic technology. This is well suited for source separated biodegradable wastes, as is the case with most plants in Germany, as well as for unsegregated MSW, as is the case with all plants in Italy and Spain. This flexibility is important for Greece, since source separation is not currently practiced and, even if it is adopted, it will take several years to be widely implemented. The above features make the MBT technology with MRF and aerobic composting particularly suitable for Greece. An additional reason is the particular suitability of this technology for MSW wastes rich in biodegradable materials.

4) Contribution of the technology to protection of the environment

The primary goal of MBT is to minimize the environmental burdens of waste disposal by way of extensive stabilization. MBT can also help to recover valuable materials.

In the mechanical stage, the first step is to sort out the disturbants (e.g. large pieces of metal), unwanted materials and - optionally - recyclables. Next, the residual waste is prepared for biological treatment by comminution, mixing and, if necessary, moistening. Then comes the biological stage, the purpose of which is to effect extensive biological stabilization of the waste. There are two basic methods of biological decomposition: aerobic decomposition, i.e. decomposition in the presence of atmospheric oxygen, and anaerobic digestion, i.e. decomposition in the absence of atmospheric oxygen, also referred to as fermenting.

The biological decomposition and conversion of organic matter by microorganisms (bacterial, protozoa, fungi) is a natural form of recycling that takes place in landfilled waste.

As biological decomposition progresses in a landfill, anaerobic digestion generates a combustible, explosive gas referred to as sanitary landfill gas. This gas escapes from the landfill and contributes to global warming and hence to climate degradation. Water seeping into the landfill, together with water contained in the waste, becomes contaminated by the products of decomposition and by the leaching out of pollutants. To keep the leachate and the landfill gas from escaping to the environment, the landfill needs to be sealed so that they can be collected and treated systematically (Dilewski, G. and Stretz, J. 2003).

Through the controlled decomposition of organic substances, mechanical-biological waste treatment substantially reduces both the gas and water emissions which would otherwise be subsequently generated at the landfill and the volume of the residual waste requiring emplacement. Waste containing a large share of biodegradable organic material is most suitable for such treatment. This is generally the case for household and commercial waste. However, contaminated waste, e.g. hazardous industrial waste; infectious waste, e.g. waste from hospitals and slaughterhouses; and construction site waste are inherently unsuitable. The suitability of industrial waste needs to be determined in advance, e.g. by analyzing, on a case-by-case basis, its pollutant concentrations and biomass fractions (Dilewski, G. and Stretz, J. 2003).

5) *Climate*

Human activities have caused a considerable increase in the greenhouse-gas contents of the earth's atmosphere. As a consequence, the earth's surface is expected to become gradually warmer over the coming decades (global warming), in turn giving rise to attendant climatic changes. The greenhouse gases that are contributing most to the greenhouse effect are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide or laughing gas (N₂O). All three of them occur internal in connection with waste disposal.

Most of the greenhouse effect attributable to waste management can be ascribed to methane, which is produced by the anaerobic digestion of biodegradable waste in landfills. Approximately one-third of all anthropogenic CH₄ emissions within the EU derive from that source. By contrast, only 1 % of the N₂O emissions and less than 0.5 % of the CO₂ emissions can be traced to landfilled waste. Hence, reducing CH₄ emissions from landfills holds the greatest potential for reducing greenhouse gas emissions in the waste-management context. MBT allows methane generation to be greatly reduced. Well-ventilated, long-term aerobic decomposition emits only about 1 % of the methane generated by a comparably sized landfill full of untreated waste. Anaerobic processes offer certain advantages over aerobic processes with regard to climatic effects because the biogas they produce contains a large proportion of methane and is therefore a useful energy vehicle, and they produce only small amounts of exhaust air, i.e. off-gas, that can scrubbed before it is released to the atmosphere.

The net greenhouse gas flux from MBT (Smith *et al*, 2001):

- The net greenhouse gas flux -403 kg CO₂ eq/tonne of MSW (high stabilize +landfill)
- The net greenhouse gas flux -329 kg CO₂ eq/tonne of MSW (less stabilize +landfill)
- The net greenhouse gas flux -137 kg CO₂ eq/tonne of MSW (high stabilize +landfill)

6) Financial requirements and costs

There are a wide range of costs dependent upon the complexity of the technology and the degree of mechanisation and automation employed (DEFRA, 2007). The table below shows indicative capital expenditure (Capex) and operational expenditure (Opex) for aerobic and anaerobic MBT facilities. These costs provided are predominantly based on European examples. Costs in the Indonesia will involve differing site specific issues such as permitting, labour, emission controls and other requirements.

Table 4 Typical MBT cost using anaerobic and aerobic processes

Capacity	Aerobic processes		AD processes	
	Capex £/t/yr	Opex £/t	Capex £/t/yr	Opex £/t
<50,000	70 – 150	up to 140	160 – 420	From 23
>50,000	28 – 225	20 – 69	107 – 278	16 – 69

(Source: DEFRA, 2007)

Information from Germany suggests that MBT costs are around 87 Euro/t, including landfill disposal fees. However, since waste management charges in Germany are usually at the upper end of the range for other member states, it has adopted lower figures for the EU as a whole. It has selected figures of 60 Euro/t for MBT with landfill and 75 Euro/t for MBT with incineration. These figures are slightly higher than the composting, AD and incineration figures to reflect the extra processing (separation) stages necessary for MBT (Smith *et al*, 2001).

7) References

Mechanical Biological Treatment of Municipal Solid Waste. Department for Environment, Food, and Rural Affairs (DEFRA), UK

Dilewski, G. and Stretz, J. 2003. Sector Project Mechanical-biological Waste Treatment, Final Report. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Germany

Arneftis, J., Naxakis, G., and Economopoulos, A.P. Design Configuration and Cost Analysis of Aerobic Mechanical-Biological Treatment Plants for MSW. Department Of Environmental Engineering, Technical University Of Crete, Chania.

Smith, A., Brown, K., Ogilvie, S., Rushton, K., and Bates, J. 2001. Waste Management Options and Climate Change, Final report to the European Commission, DG Environment. AEA Technology, Culham.

ⁱ This fact sheet has been extracted from TNA Report - Mitigation for Indonesia. You can access the complete report from the TNA project website <http://tech-action.org/>