

# Advanced Biological Treatment of Municipal Solid Waste



This Waste Management Technology Brief is one of a series of documents prepared under the New Technologies work stream of the Defra Waste Implementation Programme. The Briefs are addressing potentially important new technologies which may have an increasing role in diverting Municipal Solid Waste (MSW) from landfill into a more sustainable and integrated waste management alternative, extracting materials and energy from MSW for recovery and reducing quantities remaining for disposal. Other titles in this series include: An Introductory Guide to Waste Management Options; Mechanical Biological Treatment & Mechanical Heat Treatment; and Advanced Thermal Treatment.

It should be noted that these documents are intended as guides to each generic technology area and for more detailed or specific information on any particular technology, it is recommended that the Defra Waste Technology Data Centre is used as a resource. These Briefs deal primarily with the treatment and processing of unsorted MSW and not source segregated wastes which are addressed by the activities of the Waste & Resources Action Programme (WRAP). Relevant references and sources of further information are cited throughout each document in this series.

The prime audience for these Briefs are local authorities, in particular waste management officers, members and other key decision makers for MSW management in England. For further information on new technologies contact the New Technologies Supporter Helpline on 0870 2409894, email: [Wastetech@enviros.com](mailto:Wastetech@enviros.com).

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# Introduction

Municipal Solid Waste (MSW) is waste collected by or on behalf of a local authority. It comprises mostly household waste and it may include some commercial and industrial wastes. Nationally, the quantity of MSW is currently increasing year on year, presenting a growing problem for local authorities particularly as new legislation, which limits (by implication<sup>1</sup>) the amount of mixed MSW that can be sent to landfill, comes into effect.

One of the guiding principles for European and UK waste management has been the concept of a hierarchy of waste management options, where the most desirable option is not to produce the waste in the first place (waste prevention) and the least desirable option is to dispose of the waste with no recovery of either materials and/or energy. Between these two extremes there are a wide variety of waste treatment options that may be used as part of a waste management strategy to recover materials (for example furniture reuse, glass recycling or organic waste composting) or generate energy from the wastes (for example through incineration, or digesting biodegradable wastes to produce usable gases).

At present more than 75% of all MSW generated in England is disposed of in landfills. However, European and UK legislation has been put in place to limit the amount of biodegradable municipal waste (BMW) sent for disposal in landfill. The diversion of this material is currently the most significant challenge facing the management of Municipal Solid Waste in the UK.

There are a wide variety of alternative waste management options and strategies available for dealing with Municipal Solid Waste to limit the residual amount left for disposal to landfill. The aim of this guide is to provide impartial information about the range of technologies referred to as Advanced Biological Treatment (ABT). These technologies are part of a range of new alternatives currently being assessed and investigated through the New Technologies work stream of Defra. Further details about the new technologies featured in this report are available from Defra's Waste Technology Data Centre:

<http://www.environment-agency.gov.uk/wtd>

The technologies described in this Brief - Advanced Biological Treatment - have a limited track record in England (and the UK) processing MSW. On the continent many of these processes are established viable and bankable. The aim of this document is to raise awareness and help bring the UK up to that standard.

Some of the technologies (anaerobic digestion in particular) have had wider usage in the UK in other industries such as sewage sludge treatment and in agriculture applications. These Briefs concern mixed MSW processing and most advanced biological treatment processes require the waste to be separated into an organic rich fraction prior to processing in an ABT plant. This separation may be achieved using techniques such as those described in the Mechanical Biological Treatment Brief. This guide is designed to be read in conjunction with the other Waste Management Technology Briefs in this series and with the case studies provided on Defra's Waste Technology Data Centre. Other relevant sources of information are identified throughout the document.

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<sup>1</sup>Targets pertain to the biodegradable fraction

### Advanced Biological Treatment (ABT) and Mechanical Biological Treatment (MBT)

Clearly any biological process can only act on biodegradable materials. Therefore any ABT process can only degrade either source segregated materials or those mechanically separated from a mixed waste stream into an organic rich fraction (e.g. MBT). Some ABT processes may be used to treat mixed MSW as a pre-treatment process prior to separation (see MBT Brief).

This document is dealing with materials derived from MBT or similar processes. Source segregated collections will provide a more pure organic stream but may not capture a high enough percentage of relevant materials to achieve the required level of landfill diversion in isolation. Additional material could be separated through a MBT process. Advanced biological treatment for source separated wastes are addressed through the WRAP Organics programme<sup>2</sup>.



*In-vessel composting*

MBT is a generic term for a combination of mechanical centralised sorting of MSW which may be configured to produce a variety of outputs. It may also have a biological treatment element as part of the treatment/separation process. This Brief considers where MBT processes produce a separated biodegradable fraction for processing in an ABT plant. For more detail on MBT see the separate Brief in this series.

In line with the EC Landfill Directive, and national recycling targets, common aims of MBT plants include the:

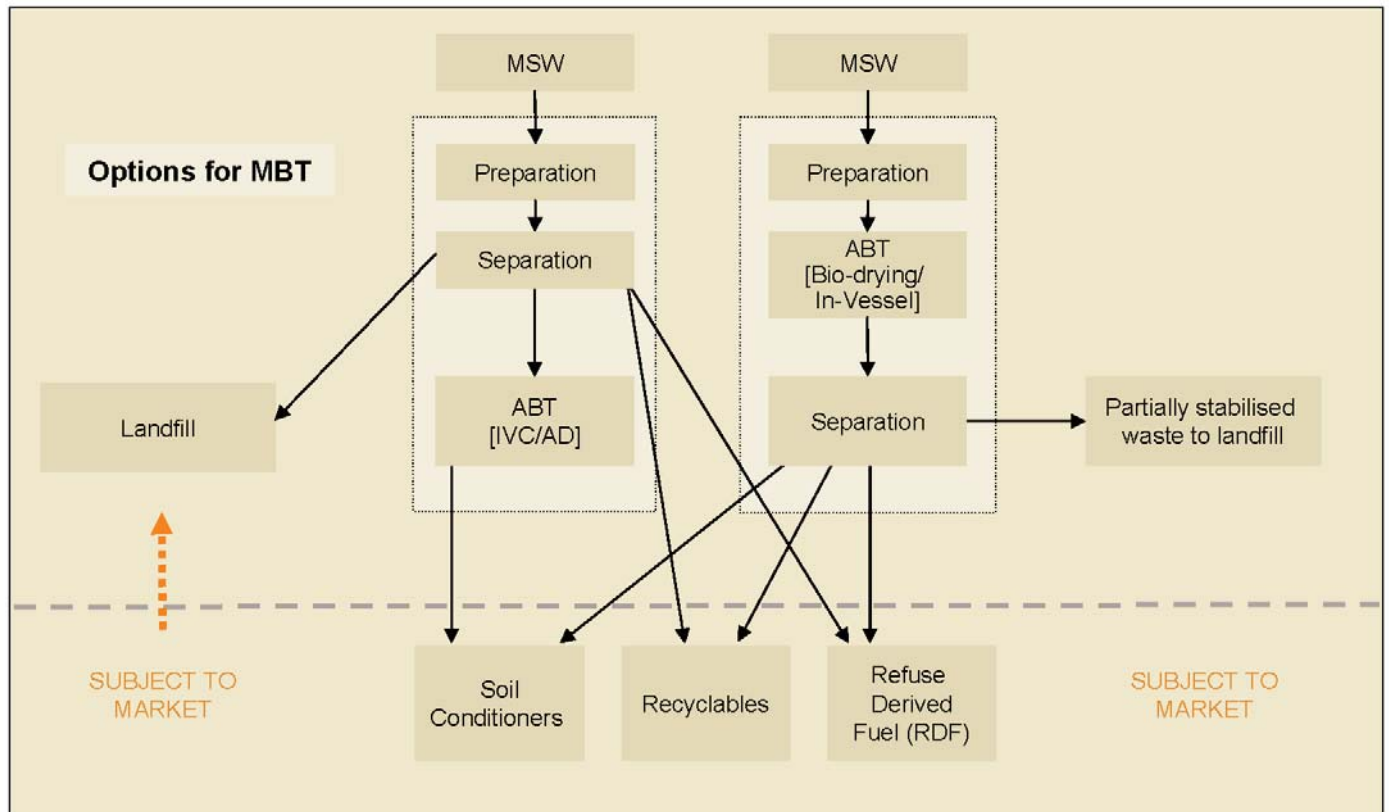
- Pre-treatment of waste going to landfill;
- Mechanical sorting of non-biodegradable MSW into materials for recycling and/or energy recovery as refuse derived fuel (RDF);
- Diversion of biodegradable MSW going to landfill by:
  - Reducing the dry mass of BMW prior to landfilling;
  - Reducing the biodegradability of BMW prior to landfill;
  - Producing a 'soil conditioner' output for land application;
  - Producing a combustible biogas for energy recovery; and/or
  - Producing a dried high calorific organic fraction for use as RDF.

MBT plant may be configured in a variety of ways to achieve the required treatment and separation of MSW. Figure 1 illustrates two concepts for MBT and highlights the ABT component within each. Further detail is provided in the case studies (page 9) and on the Waste Technology Data Centre concerning different configurations of plant.

<sup>2</sup> <http://www.wrap.org.uk/materials/organics/>

# How it Works

Figure 1 : MBT & ABT diagram



## Advanced Biological Treatment (ABT) Options

Advanced biological treatment is concerned with the use of technologies to treat biodegradable wastes using tightly controlled biological processes.

All biological waste treatment processes involve the decomposition of biodegradable wastes by living microorganisms (microbes) - bacteria, actinomycetes and fungi - which use waste materials as a food source for growth and proliferation.

These microbes excrete specialised chemicals (enzymes) to digest complicated organic substances in waste (e.g. complex carbohydrates, proteins and fats) into simple nutrients (e.g. sugars, amino acids, fatty acids) that are absorbed for microbial nutrition. As the microbes grow they convert a significant proportion of the organic matter into heat, gases and water - which can account for large mass losses during biological waste treatment.

There are two main types of conditions in which such microbes live, and therefore two main types of

biological processes used to treat biodegradable waste:

- Aerobic - in the presence of free oxygen; and
- Anaerobic - in the absence of free oxygen.

## Aerobic (composting) process characteristics

During aerobic decomposition organic material is converted into a residual solid, heat, carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O) through microbial respiration in the presence of oxygen (Figure 2).

A relatively dry process, it is used for materials with high solids content - moisture/content ratio of 40 to 60%.

Aerobic processes create large amounts of biologically produced heat as microbes respire and are associated with high (thermophilic) temperatures 55 - 70°C.

Such high temperatures, if maintained and controlled have the advantage of sanitizing the material (killing potentially pathogenic organisms) and drying the material.

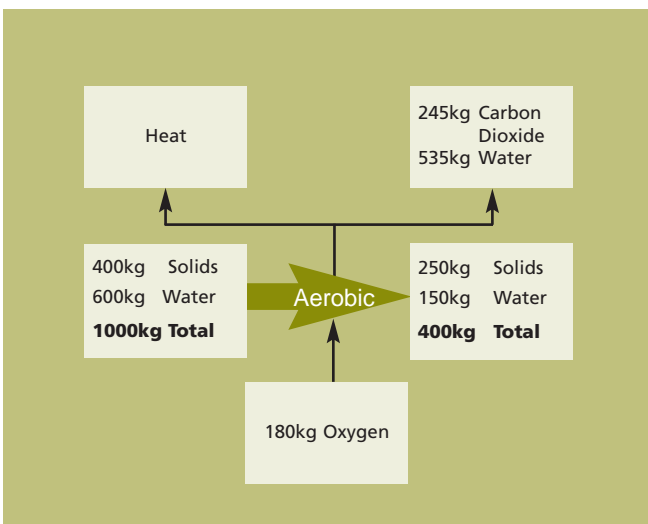


*In-vessel composting tunnel*

As the process progresses, heat, carbon dioxide and moisture are lost to the atmosphere, leaving a mixture of woody fragments, microbes, and a complex decomposition by-product called humus.

This stable, dried organic mixture together with any non-biodegradable material already in the process is known as 'compost' when produced from source segregated organic waste; or 'stabilized biowaste' when produced from non source segregated waste.

**Figure 2 : Typical Aerobic Decomposition**



## Anaerobic biological process characteristics (Anaerobic Digestion)

During anaerobic digestion (AD) organic material is converted into a residual solid and/or slurry, methane (CH<sub>4</sub>), carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O) through microbial fermentation in the absence of oxygen (Figure 3).

This process can be divided into four steps: hydrolysis, acidogenesis, acetogenesis, and methanogenesis (Table 1).

**Table 1 : AD Process steps**

Hydrolysis	Complex organic compounds converted into soluble sugars, fats, and amino acids
Acidogenesis	Above converted into organic acid, alcohols, carbon dioxide, hydrogen, and ammonia
Acetogenesis	Above converted into acetic acid, carbon dioxide and hydrogen
Methanogenesis	Above converted into methane and carbon dioxide

AD is a wet process used for materials with low solids content and moisture contents ranging between 60 to 95%. Anaerobic processes create much lower amounts of biologically produced heat and additional heat may be required to maintain optimal temperatures at 35 to 40°C.

A combustible gas known as 'biogas' is produced, primarily consisting of a mixture of methane and carbon dioxide - which can be used for heat and/or electricity production. As well as biogas, a complex mixture of microbes (biomass), decomposition by-products, humus and woody fragments remain in a liquid suspension known as 'digestate'.

# How it Works

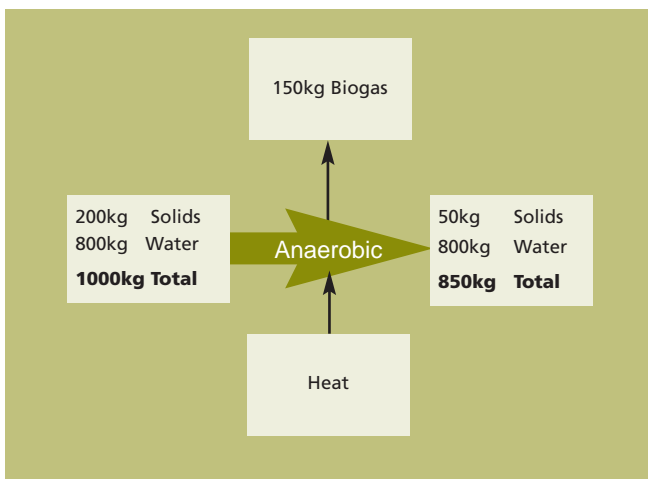


Anaerobic Digester in Tel Aviv

Due to the high moisture content of the waste material entering the process and the loss of solids during digestion, the final digestate still contains high moisture content upon leaving the process. This digestate can be mechanically separated into its solids (fibre) and liquid (effluent) fractions.

The dewatered fibre may be used directly on land as a soil improver provided it meets appropriate regulatory criteria (see page 10), or aerobically treated (matured through a composting process) prior to its use. The liquid effluent may be recycled in the AD process, used directly as a liquid fertilizer if meeting appropriate criteria, or used in subsequent aerobic (composting) treatment of the fibre.

Figure 3 : Typical Anaerobic Digestion



## Aerobic (composting) technologies

Aerobic treatment (composting) technologies come in a range of designs. All systems supply oxygen and control temperature and moisture levels to optimise the biological stabilisation, achieve sanitisation, and/or, in some cases, drying.

The composting technologies described here are all enclosed either in buildings and/or specifically designed vessels (e.g. tunnels, drums, towers). The methods used to control oxygen supply, temperature and moisture loss are through mechanical agitation and/or forced aeration (fan assisted). Each system offers differing methods of material flow and handling, and process automation (see Table 2).

Table 2 : Technology Options

System	Flow	Aeration
Tunnels	Batch	Forced aeration
		Forced aeration, mechanical agitation
	Continuous	Forced aeration
		Forced aeration, mechanical agitation
Vertical composting towers and silos	Continuous	Forced aeration, mechanical agitation
		Forced aeration
		Passive aeration
Agitated bays	Continuous	Mechanical agitation
Extended beds	Continuous	Forced aeration, mechanical agitation
Rotating drums	Continuous	Forced aeration, mechanical agitation



## Tunnels

Tunnel composting units are large-scale rectangular vessels employing forced (fan) aeration systems. They can be built as permanent structures constructed from concrete and steel, or as more temporary structures using mobile concrete push walls and/or special fabrics stretched over steel frames. Tunnels may be single or double ended for loading and unloading, and may be fitted with retractable or opening roofs to help load or unload.

Typically, composting tunnels are used to process materials in single batches (all in/all out), although some systems operate on a continuous flow using specially designed moving floors, or agitation systems (e.g. augers) to continuously load and unload material. Tunnels can be filled manually using loading vehicles fitted with buckets or using specialised filling equipment, such as loading conveyors.

Aeration is achieved by blowing and/or sucking air through a slatted floor, perforated pipe-work, or special aeration channels. Oxygen and temperature are controlled by adjusting the amount of cool fresh air entering the system, the amount of air recirculated, and the rate of flow within the system. Odorous gases are controlled by passing exhaust air through water and/or chemical air scrubbers, bio-filters, thermal or ozone based oxidising units.

Moisture may be controlled by pumping leachate and/or fresh water through a spray-bar positioned in the roof of the tunnel onto material being processed.

## Vertical composting towers and silos

Material is fed on a continuous basis into the top of a sealed tower or silo, and is processed as it moves vertically through the vessel. These systems may consist of a number of vessels with a single compartment, or a single larger vessel with several compartments (or levels).

The rate at which material moves through the system is controlled by the rate at which finished processed material is removed from the bottom of the vessel. In single compartment systems, once the material has had the required processing time in the vessel, it is removed from the bottom using augers or scraping arms. As compost or stabilised biowaste

is removed from below, the material above moves down under gravity filling the space created.

Many tower/silo systems rely on passive aeration, but some systems also use forced aeration.

## Agitated bays and Extended beds

Organic material is fed into a large enclosed building for processing. The material is either placed in long concrete-walled bays, or extended beds ('mattresses').

Material is turned with specialist turning machines comprising rotating drums with tines, augers, or elevated-face conveyors. Turners can be mounted on top of bay walls, or driven through the bay or on the floor of the processing building. Unmanned remote controlled turners are also used, consisting of bucket-wheels or augers suspended from mobile gantries in the roof of the processing building.

During the turning process material is moved along the length of a bay or processing building in a continuous flow fashion. In many cases, the floor of the processing building is also fitted with a forced aeration system, often using negative pressure (suction) to prevent odours escaping and improve working conditions inside the building.

## Rotating drums

This is a continuous processing system where material is fed into a large, rotating drum. The material is agitated and aerated as it passes along the drum. Material is mixed, aerated and moved along the length of the drum by means of specially designed baffles and tines situated in its walls. Some systems also employ forced aeration rather than relying on passive air flow alone.

The mechanical action of rotating drums is often used to split refuse bags and reduce the particle size of waste materials, as well as dry material, to aid mechanical sorting rather than stabilisation.

## Bio-drying

Where composting technologies are applied to 'dry' the waste this is usually as part of a pre-treatment process, e.g. in an MBT plant, and is often referred to as 'bio-drying'. This concept of bio-drying is to force air through the waste to dry it in a short time period, reducing its mass and partially degrading the

## How it Works

material. This makes the waste more amenable to mechanical separation and of a greater calorific value if used as a fuel.

A number of the techniques above may be used as the basis for bio-drying including tunnels and extended beds or bays.

### Anaerobic (Biogas) Digestion Technologies

Waste feedstock is macerated with a large proportion of process water to provide a dilute thin ('wet') or thick ('dry') slurry that can be fed into a digester tank. This stage also provides a useful decontamination stage to remove heavy and light contaminants through wet gravimetric separation.

The AD process can be operated at mesophilic (typically 30 - 40°C) or thermophilic (typically 50 - 60°C) temperatures (see Table 3). Dry AD processes lend themselves to thermophilic temperatures, whereas wet processes can be either meso- or thermophilic with the former being dominant. The EU Animal By-Products Regulations (ABPR) require pasteurisation of mixed source AD waste to a standard of 70°C for one hour. UK legislation requires treatment of 70°C for one hour or 57°C for 5 hours.

The digestion process takes place in sealed tanks (digesters) that are usually mixed thoroughly to maximise contact between microbes and waste. Mixing can be achieved using mechanical stirring devices, gas or slurry recirculation.

AD processes can be single step processes where all the waste is placed into a single digestion stage/tank or multiple step processes (table 4).

Multiple step processes involve a separate hydrolysis stage, which can be either aerobic or anaerobic, to optimize the breakdown of complex organic material into soluble compounds. This is followed by a high-rate AD process for biogas production. This process may take place in a number of vessels, normally two are employed, one as a separate hydrolysis vessel and the second as a digester.

Table 3 : Mesophilic & Thermophilic Anaerobic Digestion

Parameter	Mesophilic	Thermophilic
Temperature	30 - 40°C	50 - 60°C
Residence time	15 - 30 days	10 - 20 days
Total solids (wet)	10 - 15%	10 - 15%
(dry)	20 - 40%	20 - 40%
Advantages	More robust and tolerant process than thermophilic	Higher gas production Faster throughput Process more sensitive to environmental variables
Disadvantages	Lower gas production rate, hence larger digestion tanks Separate sanitization stage	Needs effective control Separate sanitization stage

Some case study examples are described below and further information on these and additional specific examples can be obtained from the Waste Technology Data Centre<sup>3</sup>.

Table 4 : Anaerobic Technology options

Temperature range	Wet/Dry	Process Stages
Mesophilic	Wet	Single
		Multiple
	Dry	Single
		Multiple
Thermophilic	Wet	Single
		Multiple
	Dry	Single
		Multiple

<sup>3</sup> [www.environment-agency.gov.uk/wtd](http://www.environment-agency.gov.uk/wtd)

### Case Studies

#### Bio Degma (in-vessel composting)

This is an in vessel composting process. It is developed from agricultural based technology. In this instance the waste processed is source segregated green waste either from kerbside or Civic Amenity site collection.

The received waste is shredded. The compost tunnels are of a three-sided concrete construction and typically 6.5 m wide x 21 m long x 2 m high, with a capacity of 280m<sup>3</sup>. The pitched roof and double front-opening tunnel doors are covered in a three-layered Gortex™ type membrane material which is both waterproof, but at the same time allows water vapour to pass through and escape. The organic fraction is placed in the enclosed tunnels by a front-end loader. The membrane roof is closed and the under floor aeration channels aerate the waste so as to maintain a pre-set temperature. Residence time in the composting tunnels is a minimum of 3-4 weeks.

#### CAMBI Lillehammer, Norway (anaerobic digestion)

This process located close to the picturesque town of Lillehammer, uses thermal hydrolysis of the renewable content of MSW followed by anaerobic digestion to produce a biogas that is burnt in an engine generator set. The use of a hydrolyser results in more of the degradable material in the feed being converted into biogas.

The key process stages include MSW reception, shredding, and a wet separator, where the biodegradable material is separated from the reject material. A thermal hydrolysis stage is a feature of this system followed by a one stage anaerobic digestion process. The AD plant utilises the biogas produced in an engine powered generator with waste heat recovery that provides the steam and heat to the hydrolyser and digesters.

It is accepted that the rate-controlling step in the anaerobic digestion of MSW is the hydrolysis of complex materials such as cellulose, in paper and leaves etc., into small soluble molecules such as glucose, which can then be digested. This process is accelerated by heating the material under pressure to around 150°C. This results in substantially more of the biodegradable material being made available for conversion into gas and ensures the feed material is sterilised.

After this initial composting period the raw compost is placed in external windrows to mature for an additional 5-6 weeks. The matured compost is then trolled to remove any plastics. In a final processing step, the compost can be blended with additives (e.g. sand, brick dust, Nitrogen, Phosphorus and Potassium) to meet different specifications and bagged if required. The site offers both a collection and delivery service for customers.

#### Arrow Bio, Tel Aviv (wet MBT using anaerobic digestion)

This process uses a water based MRF (Materials Recycling Facility) to separate the biodegradable element of MSW from other materials, which are recycled. The biodegradable element is then anaerobically digested in a two-stage process. This process utilises technology well established in the water industry. The gas is used in a spark ignition engine generator to provide power and the option of supplying surplus heat. A soil conditioner is produced which appears particularly clean and consists of lignin with cellulose fibres. This is a product with beneficial use and demand in Israel for its water retention and soil structure benefits. Given that it has been produced from mixed waste it would not meet PAS100 status in the UK.

The combination of the thorough wet MRF process and an efficient anaerobic digestion gives class-leading conversions of biodegradable material into biogas.

# Markets for the Outputs

## Soil Conditioner

ABT processing of mechanically separated organics (e.g. from MBT plant) produces a stabilised and sanitised 'soil conditioner' material. The potential applications and outlets for such material will be dependent on its quality and the legislative and market conditions.

It is largely assumed that these products will be of a lower, neutral or negative value compared to those derived from source segregated materials, largely due to the increased contamination likely to be present.

A great deal of uncertainty still surrounds the potential use of such products. It is expected that such materials will be considered a 'waste', and will require a waste management license or exemption in order for use of the material in a recovery operation.

Therefore, the following guidance will undoubtedly be subject to future legislative and policy changes. For the latest position contact the Supporter helpline on 0870 2409894, [wastetech@enviros.com](mailto:wastetech@enviros.com) or the Environment Agency and Defra websites.

It is likely that the ABT product will be referred to as 'stabilized biowaste' (SBW) - to avoid confusion with 'compost' produced from source separated materials - and its application restricted to land where food and feed crops are not cultivated.

The output from ABT of organics from a mixed waste source is expected to be a low grade soil conditioner which may be utilised in applications such as landfill restoration and other low grade or contaminated land applications; as well as some other general landscaping uses as a soil improver (providing that appropriate standards are met). Table 5 shows limits on potentially toxic elements (PTE) allowed in compost/SBW for certain end-uses.

The criteria used to permit the application of SBW to land is likely to be risk-based - related to its contamination content, and the nature of the land to which it will be applied. This is similar to the way in which the use of sewage sludge on agricultural soils is regulated. However this process will be subject to appropriate test methods and limit levels for certain toxic compounds to be established.

Some waste management contractors have demonstrated that there are outlets for these materials, however it is unlikely that there will be an income from use as a soil conditioner and there may be costs associated with the spreading of SBW on land.

## Animal By-Products Regulations (ABPR)

Only MBT plants that intend to use the stabilised organic material on land (including landfill cover) will be considered to be a composting or biogas plant, and will fall within the scope of the ABPR. These sites must therefore meet all the treatment and hygiene requirements that source segregated waste composting/biogas digestion plants must achieve.

Mixed MSW contains household kitchen ('catering') waste including meat, and as such will at least fall under a UK national ABPR standard for catering waste, where meat has not been excluded. In some cases it will be difficult to guarantee the exclusion of retail and food factory waste containing raw meat or fish, which is classified as Category 3 animal by-products rather than 'catering waste'.

Category 3 animal by-products must be treated in accordance with the EU standard and related hygiene and plant management requirements.

MBT plants will require approval from the State Veterinary Service before operation, and before any of the treated material is applied to land.

Table 5 : Compost and SBW PTE limits

Parameter	Draft Biowaste Directive			BSI PAS 100*
	Class 1	Class 2	SBW	
Cadmium, ppm	0.7	1.5	5	1.5
Chromium, ppm	100	150	600	100
Copper, ppm	100	150	600	200
Mercury, ppm	0.5	1	5	1
Nickel, ppm	50	75	150	50
Lead, ppm	100	150	500	200
Zinc, ppm	200	400	1500	400
Impurities >2mm	0.5%	0.5%	<3%	0.5%; of which 0.25% maximum can be plastic
Gravel & stones	>5mm 5%	>5mm 5%	-	>4mm, <8% in grades other than course mulch >4mm in course mulch grade <17%
Pathogens				E.coli 1000cfu/g. No Salmonella in 25g

\* A prerequisite for PAS100 is that waste is source-segregated

## Track Record

Examples of Advanced Biological Treatment technologies such as in-vessel composting and AD have been proven for source segregated materials in the UK, this is not the case (to date) for commercial operations processing organics from MBT, as described below.

### Anaerobic Digestion (AD)

This technology has been proven on sewage sludge across the UK water industry, but not commercially proven on MSW, although a large plant exists in Holsworthy, Devon, co-processing food waste. The Biffa/Leicester PFI MBT plant is a large scale AD plant processing the mechanically separated organic fraction of MSW, but is in early phases of operation at the time of writing.

### Aerobic Composting

This form of technology has been commercially developed in the UK. Most UK experience of aerobic (composting) technology to date is still through open air turned pile/windrow composting. In-vessel take-up has increased due to Animal By-Product Regulations issues. In-vessel composting has been adopted for the biological process in three MBT plants built for Argyle & Bute, Scotland and also for the Neath Port Talbot plant in Wales.

### MBT technology

MBT technology has been proven in mainland Europe (see MBT Waste Management Technology Brief, in this series) and so the current issue is one of appropriate technology transfer. The UK test-bed for these technologies is now in progress, and planning permission granted for plants in East London Waste Authority (ELWA) and the Biffa plant operational in Leicester.

The least proven aspect of these technologies is probably the final quality and contamination levels of stabilised organic residues produced. There are unresolved issues regarding potential outlets for stabilised residues distributed free of charge, and potential costs of distributing such materials through other routes. Further information is available through the Supporter helpline and other reference documents such as the SITA EB report on MBT (see further reading).

## Financing

Development of ABT plant will involve capital expenditure of several million pounds. There are a number of potential funding sources for Local Authorities planning to develop such facilities, including:

**Capital Grants:** general grants may be available from national economic initiatives and EU structural funds;

**Prudential Borrowing:** the Local Government Act 2003 provides for a new 'prudential' system of capital finance controls;

**PFI Credits and Private Sector Financing:** under the Private Finance Initiative a waste authority can obtain an annual subsidy from central government through a Special Grant;

**Other Private-Sector Financing:** A contractor may be willing to enter a contract to provide a new facility and operate it. The contractor's charges for this may be expressed as gate fees; and

**Existing sources of local authority funding:** for example National Non-Domestic Rate payments (distributed by central government), credit (borrowing) approvals, local tax raising powers (council tax), income from rents, fees, charges and asset sales (capital receipts). In practice there will be limited opportunity to take advantage of these.

## Contracting

Medium and large scale municipal waste management contracts are usually procured through the negotiated procedure of the Official Journal of the European Union (OJEU) process.

The available contractual arrangement between the private sector provider (PSP) and the waste disposal authority (or partnership) may be one of the following:

**Separate Design; Build; Operate; and Finance:** The waste authority contracts separately for the works and services needed, and provides funding by raising capital for each of the main contracts. The contract to build the facility would

be based on the council's design and specification and the council would own the facility once constructed;

**Design & Build; Operate; Finance:** A contract is let for the private sector to provide both the design and construction of a facility to specified performance requirements. The waste authority owns the facility that is constructed and makes separate arrangements to raise capital. Operation would be arranged through a separate Operation and Maintenance contract;

**Design, Build and Operate; Finance:** The Design and Build and Operation and Maintenance contracts are combined. The waste authority owns the facility once constructed and makes separate arrangements to raise capital;

**Design, Build, Finance and Operate (DBFO):** This contract is a Design and Build and Operate but the contractor also provides the financing of the project. The contractor designs, constructs and operates the plant to agreed performance requirements. Regular performance payments are made over a fixed term to recover capital and financing costs, operating and maintenance expenses, plus a reasonable return. At the end of the contract, the facility is usually transferred back to the client in a specified condition; and

**DBFO with PFI:** This is a Design, Build, Finance and Operate contract, but it is procured under the Private Finance Initiative. In this case the waste authority obtains funding for future payment obligations from Government as a supplement to finance from its own and private sector sources.

The majority of large scale waste management contracts currently being procured in England are Design, Build, Finance and Operate contracts and many Waste Disposal Authorities in two tier English arrangements (County Councils) seek to partner with their Waste Collection Authorities (usually District or Borough Councils). Sometimes partnerships are also formed with neighbouring Unitary Authorities to maximise the efficiency of the waste management service and make the contract more attractive to the Private Sector Provider.

## Contractual and Financing Issues

Before initiating any procurement or funding process for a new waste management treatment facility, the following issues should be considered: performance requirements; waste inputs; project duration; project cost; available budgets; availability of sites; planning status; interface with existing contracts; timescales; governance and decision making arrangements; market appetite and risk allocation.

Further guidance on these issues can be obtained from:

Procurement Toolkit<sup>4</sup>;

For Works Contracts: the Institution of Civil Engineers 'New Engineering Contract'<sup>5</sup>;

For large scale Waste Services Contracts through PFI AND following the Negotiated Procedures the 4ps 'Waste Procurement Pack'<sup>6</sup>; and

The Local Government PFI project support guide<sup>7</sup>.

A number of PFI funded/contracted waste management projects have and will continue to involve large scale MBT technologies (some of these are shown in Table 6) mostly using some form of ABT.

Table 6 : PFI Contracts in Local Authority Waste Management including MBT technology

Year	Local Authority	Contractor	Solutions
2000	Neath Port Talbot	HLC	MBT with In-Vessel composting + EfW
2003	East London	Shanks	2 MBT with Bio-drying
2003	Leicester	Biffa	MRF + AD
	Dumfries/Galloway	Shanks	MBT with In-Vessel composting
In progress	Central Berkshire	TBC	Civic amenity sites + MRF - MBT
In progress	Lancashire	TBC	4 MBT + 5 Transfer Stations
In progress	Cambridgeshire	TBC	2 MBT, EfW, AD
In progress	Northumberland	TBC	3 Civic Amenity sites, MRF, MBT, composting

<sup>4</sup> <http://lasupport.defra.gov.uk/Default.aspx?Menu=Menu&Module=Article&ArticleID=102>

<sup>5</sup> [www.ice.org.uk](http://www.ice.org.uk)

<sup>6</sup> [www.4ps.gov.uk](http://www.4ps.gov.uk)

<sup>7</sup> [www.local.odpm.gov.uk/pfi/grantcond.pdf](http://www.local.odpm.gov.uk/pfi/grantcond.pdf)



## Planning

Obtaining planning consent to develop a large scale ABT facility can represent a significant risk, for the contractor and/or Local Authority, which can delay or frustrate delivery of the project.

## Site Criteria

*Existing land use:* Preference should be given to industrial or degraded sites, or sites on/close to, existing waste management facilities.

*Proximity to sensitive receptors:* Concerns over health risks from bio-aerosols generated by biological treatment processes may require plants to be located at least 250m from sensitive receptors.

*Access:* Access consideration will be directly related to the volume of waste. If part of a centralised facility, which includes other process operations, sites should normally be located close to the primary road network without constraints on large numbers of HGVs and waste collection vehicles.

## Environmental Impact Assessment (EIA)

Some small ABT/MBT facilities may not require EIA. However, the majority will be combined processes likely to require EIA under Schedule II - Part 11 'Other Projects' (b) installations for the disposal of waste - of the EIA Regulations.

## Pollution Prevention and Control (PPC) Permit

Pollution Prevention and Control is a regime for controlling pollution from certain industrial and waste activities. The regime introduces the concept of Best Available Techniques (BAT) to environmental regulations. Operators must use the BAT to control pollution from their activities. The aim of BAT is to prevent, and where that is not practicable, to reduce to acceptable levels, pollution to air, land and water. BAT also aims to balance the cost to the operator against benefits to the environment.

The system of Pollution Prevention and Control (PPC) is replacing that of Integrated Pollution Control (established by the EPA 1990) and is taking effect between 2000 and 2007. The PPC regime implements the European Directive (EC/96/61) on integrated pollution prevention and control. Prior to

commencing operations, ABT/MBT facilities are likely to require a PPC Permit under Section 5.3, Part A(1)(c) of Schedule 1 to The Pollution Prevention and Control (England and Wales) Regulations 2000.

## Animal By-products Regulations (ABPR)

Any MBT/ABT type facility producing a stabilised organic output to land will be required to meet EU ABPR standards for processing Category 3 animal by-products or, at least, national ABPR standards for 'catering' waste containing meat (see table below). The EU ABPR standard requires that all material be either anaerobically digested or composted at 70°C for at least 1 hour with a maximum feedstock particle size of 12 mm.

Table 7 : National ABPR minimum standards

AD (one process stage below, plus storage)	Composting* (any 2 process stages listed below)
70°C; 1 hour; max particle size 60mm	Enclosed reactor 70°C for at least 1 hour with a maximum particle size of 60mm
57°C; 5 hour; max particle size 50mm	Enclosed reactor 60°C for at least 2 days with a maximum particle size of 400mm
At least 18 days storage (may be in the open)	Housed (if first stage) or open air (if second stage) turned piles. 60°C; 2 days achieved 4 times consecutively, with a turning between each; max particle size of 400mm

\* Two processing stages can be achieved in one reactor where an internal mixing process is used.

Premises must be enclosed from waste reception until at least the completion of the first processing stage. The processing site must also prevent access to animals and birds, which could act as potential pathogen vectors. Partially or fully treated material must not be contaminated with any material that has been treated to a lesser extent. There must be no way that any untreated or partially treated materials can by-pass the pasteurisation and storage stages within the system.

# Planning and Permitting Issues

To ensure all these process and hygiene standards are met, strict operating, monitoring, and hygiene procedures must be followed according to a Hazard Analysis and Critical Control Point (HACCP) plan. The HACCP plans must be developed and verified (through site checks and microbial analysis of samples) as part of the ABPR approval process.

## Land and Resource Requirements

ABT plants can be built for a wide range of capacities. The chosen scale will reflect the tonnage necessary to meet local waste strategy targets and make the facility profitable within the conditions of the contract, within the limitations of local planning and permitting restrictions. Most ABT facilities in this context will be associated with MBT plant and the capacities of which may range anywhere from 15,000 tonnes per annum to 500,000 tonnes per annum. Although, a capacity of around 100,000 is typical for large scale waste service contracts in the UK.



Anaerobic Digestion facility, Lillehammer

Depending on the front-end separation techniques used, differing volumes of centrally separated organic waste will require biological treatment.

The scale of the biological process depends on the total material throughput, and the residence time of the material in the biological process. In general AD processes require shorter residence times and so are smaller in scale. However, often AD facilities will need to be followed by an aerobic (composting) process to complete stabilisation, and dry the digestate.

Different residence times will relate to regulatory requirements (e.g. ABPR), the efficiency of the process, and parameters required for the final output (e.g. moisture content, stability/respiration rates), and output end use.

Typical operating parameters for the biological treatment process for MBT plants are given below (see Table 8).

Table 8 : Facility Capacity and Parameters

Family type	Aerobic (composting) processes	Anaerobic (biogas) processes
Capacity '000 t/yr	up to 250	up to 250
Buildings m <sup>2</sup> /t/yr	0.05 to 0.1	0.05 to 0.1
Vessels/building height	8 to 20m*	8 to 25m**
Capacity '000 t/yr	0.1 to 0.8	0.1 to 0.8†
Operational staff required per 1000 tonnes	0.5 to 1.0	0.2 to 0.4
Vehicle movements per tonne ‡	0.1 to 0.3	0.1 to 0.3

\* Taller buildings/vessels indicated are for vertical composting technology

\*\* Lower building/vessels indicated are for horizontal digesters

\*\*\* This does not include space for post digestate composting/maturation

† Depends on the amount of automated materials handling and nature of process, e.g. bio-drying takes much less space

‡ Depends on the average payloads of delivery vehicles

## Environmental Considerations

The primary emissions from these plants are emissions to air and the limited potential for discharges to water by leachate and land impacts from the application of soil conditioners. This section details some of the potential impacts from these emissions.

## Nutrient Retention

Biological processes (both aerobic and anaerobic) offer the opportunity for key nutrients including Nitrogen, Phosphorus and Potassium and other trace metals to be retained in the agricultural/horticultural cycle. This is in contrast to the thermal processes, where bulk of the nutrients are either lost to a different medium or removed completely from the natural cycles.

## Odour

As one of the most conspicuous potential emissions of any biological treatment of biodegradable waste, odour needs extremely careful consideration. As most ABT technologies are almost entirely enclosed, potential odour emissions will normally be extensively controlled through large ventilation and air scrubbing and filtering systems.

## Bio-aerosols (and Dust)

Bio-aerosols are biological particles suspended in air and can be either whole or fragments of living or dead microbes, or their spores. They have the potential to cause respiratory complaints if inhaled in large quantities. Bioaerosols are more associated with the agitation of dry materials. However, emissions can be controlled through the use of enclosed vessels, and negative pressure within buildings. Most or all of such emissions from an MBT/ABT plant should be mostly absorbed by the odour treatment systems.

## Water Resources

The release of potentially harmful chemicals into surface and/or ground water is only likely where there is uncontrolled leachate and/or run off from the working areas contaminated with waste materials. Most ABT will have tight control of such emissions through extensive impermeable surfaces, drainage, and hygiene procedures as required under ABPR.

# Social and Perception Issues

## Social Considerations

Any new facility will potentially impact on local residents both positively and negatively. Potential environmental and local amenity impacts, whether real or perceived, can cause a great deal of concern. MBT and associated ABT plants are large facilities that should be sited carefully, to minimise these impacts (see page 16).

MBT and associated ABT facilities may also provide positive social impacts in the form of employment and educational opportunities. Table 8 provides an estimate of the jobs created by a new plant. These facilities are also likely to provide vocational training for staff. Many new facilities are built with a visitors centre to enable local groups to view the facility and learn more about how it operates.

## Public Perception

### Public Opinion

Public opinion on waste management issues is wide ranging, and can often be diverse. Typically, the most positively viewed waste management options are recycling and composting. This is not necessarily reflected in attitudes towards the infrastructure required to deliver recycling and composting, and it should be recognised that there is always likely to be some local resistance to a new waste management facility.

At present there is a relatively low level of public understanding on the concept of ABT. However it would be anticipated that biological processing of waste, in line with the concept of composting, may receive a more positive reaction than other alternative waste management options.

## Costs of MBT with Advanced Biological Treatment

In this section, the cost of constructing, operating and maintaining MBT with anaerobic and aerobic processes is discussed.

The costs included are derived from the Waste Technology Data Centre and published studies. They may be considered as indicative costs in terms of relative comparison (Table 9). These costs are predominantly based on European examples. Costs in the UK will involve differing site specific issues such as permitting, emission controls and other requirements. Many of these costs are also based on pre-treatment before landfill or incineration, rather than producing useable marketable outputs, which in some cases may create extra costs.

The variation in magnitude and ranges presented in some instances are due to the wide variety of systems available on the market, plant capacities, and the level of mechanical automation used.

It should also be noted that MBT costs are sensitive to the markets for recycled products, RDF and soil conditioners that are produced by different processes. The impact of the loss of markets for these materials is not reflected in these costs.

Table 9 : Indicative MBT cost using Anaerobic and Aerobic processes

Capacity	Aerobic process		AD processes	Average Range
	Capex £/ty	Opex £/ty	Capex £/ty	Opex £/ty
<50,000	50 - 300	30 - 60	150 - 400	25 - 60
100,000	50 - 200	33	50 - 122	21
200,000	85 - 200	28	50 - 175	18
500,000	20 - 50	15 - 27		

Sources: Waste Technology Data Centre 2004, AiE 2003.

# Contribution to National Targets

## Best Value Performance Indicators (BVPI)

### BVPI 82b: Composting and Anaerobic Digestion

Where Mechanical Biological Treatment is configured (through an ABT process) to produce an organic rich stream to be utilised as a low grade soil conditioner for example, this material may qualify as composting under BVPI 82b. These types of mixed waste processing technologies are expected to produce a low grade soil conditioner which may be utilised in applications such as landfill restoration or some bulk fill uses (provided that the appropriate engineering standards are met).

These materials will only qualify as 'composted' under the Best Value Performance Indicators (BVPI 82b) if the output meets the appropriate criteria for use in the intended application. Some waste management contractors have demonstrated that there is a market for these materials, however the current Best Value Performance Indicator Guidance (as of November 2004) states the criteria for composting should be '*a product that has been sanitised and stabilised, is high in humic substances, and can be used as a soil improver, as an ingredient in growing media or blended to produce a top soil that will meet British Standard BS2882 incorporating amendment no.1...*' It also states that it is '*unlikely that products of a Mechanical Biological Treatment process will meet this definition.*' However if the requirements of the definition could be achieved then the product would qualify as BVPI 82b.

The definition of BVPI 82b has been amended to include waste which has been treated through a process of anaerobic digestion.

Where MBT products do not meet this definition, it will not be eligible for inclusion in BVPI 82b.

For the latest position with regard to Best Value Performance Indicators for MBT and MHT see the BVPI website<sup>8</sup> or contact the Supporter Helpline tel. 0870 2409894 [Wastetech@enviros.com](mailto:Wastetech@enviros.com)

## Waste and Emissions Trading (WET) Act 2003 - Landfill Allowance Trading Scheme (LATS)

LATS started on the 1st April 2005 and will see progressively tighter restrictions on the landfilling of Biodegradable Municipal Waste (BMW) in line with the landfill directive targets. Local authority allowances for the amount of BMW they can send to landfill have been calculated in proportion to their total MSW arisings. This in turn is based on the fraction of the national total of BMW allowed to be landfilled according to the Landfill Directive.

ABT will be able to contribute to these targets in a number of ways: 1) BMW may be converted into a soil conditioner; 2) BMW may be sent for incineration as RDF; and 3) BMW may be reduced in dry mass and biodegradability prior to landfill.

The ability of MBT to meet a high level of landfill diversion through the production of RDF or soil conditioner will largely depend upon the availability of markets/outlets for these materials. BMW diversion through mass reduction and stabilisation prior to landfill will require more complex calculations when considering targets.

The Environment Agency (EA) are currently developing a methodology to determine the 'biodegradability' of stabilised materials. This test will be used to determine the amount of 'biodegradable' material being landfilled. It is likely that the biodegradability of material will be based on dry matter content, and that simply reducing the materials total mass through 'bio-drying' may not count.

As any MBT plants developed in the UK are likely to vary in their method of operation, the stability test is likely to be applied to each MBT plant on a regular basis. The EA have consulted on which test to adopt to determine 'stability' and the results will be published in the near future. Up to date information relating to LATS can be obtained from the New Technologies Supporter Helpline and Defra's LATS information webpage<sup>9</sup>.

<sup>8</sup> <http://www.defra.gov.uk/environment/waste/localauth/index.htm>

<sup>9</sup> <http://www.defra.gov.uk/environment/waste/localauth/lats/index.htm>

### Renewable Obligation Certificates (ROCs)

The Renewables Obligation came into force in April 2002 as part of the Utilities Act (2000). It requires power suppliers to source a specified proportion of the electricity they supply to their customers from renewable generation. This starts at 3% in 2003, rising gradually to 10% by 2010, and 15% by 2015.

Eligible renewable generators such as biogas plants receive ROCs for each MWh of electricity generated. These can then be sold to suppliers, in order to fulfil their obligation. Suppliers can pay a 'buyout' price of £30 up to £45 per MWh for any shortfall. Biogas electricity production per tonne of waste can range from 75 to 225kWh, giving a potential ROCs value of £2.25 to £6.75 per tonne of waste processed, but prices are not guaranteed.

## Further Sources of Information

The Waste Technology Data Centre [www.environment-agency.gov.uk/wtd](http://www.environment-agency.gov.uk/wtd)

New Technologies Supporter Helpline  
Tel. 0870 240 9894 E: [Wastetech@enviros.com](mailto:Wastetech@enviros.com)

Defra New Technologies website  
<http://www.defra.gov.uk/environment/waste/wip/newtech/index.htm>

Integrated Pollution Prevention and Control, Draft Reference Document on Best Available Techniques for the Waste Treatments Industries, *European Commission - Directorate General Joint Research Centre*, January 2004

WRAP Organics website  
<http://www.wrap.org.uk/materials/organics/>

The Composting Association, including reports on Anaerobic Digestion and Directory of In-Vessel Composting. [http://www.compost.org.uk/dsp\\_home.cfm](http://www.compost.org.uk/dsp_home.cfm)

Chartered Institution of Wastes Management.  
<http://www.ciwm.co.uk>

Mechanical Biological Treatment: A Guide for Decision Makers, Processes, Policies and Markets (2005), by Juniper consultancy Ltd for Sita Environmental Trust.  
<http://www.sitaenvtrust.org.uk/research/overview>

Defra (2004) *Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes*.

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Friends of the Earth, Residuals Report

Defra (2001) *Guidance on Municipal Waste Management Strategies; and Best Value Performance Indicators for Frequently Asked Questions for 2004/05* at:  
[http://www.defra.gov.uk/environment/waste/localauth/bvpi\\_faq.pdf](http://www.defra.gov.uk/environment/waste/localauth/bvpi_faq.pdf)

Office of the Deputy Prime Minister's guidance:  
[http://www.odpm.gov.uk/stellent/groups/odpm\\_localgov/documents/page/odpm\\_locgov\\_609123-10.hcsp](http://www.odpm.gov.uk/stellent/groups/odpm_localgov/documents/page/odpm_locgov_609123-10.hcsp)

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GLA (2003) Supporting documentation for City Solutions Conference: <http://www.london.gov.uk/mayor/strategies/waste/wasteconfce.jsp#docs>

Associates in Industrial Ecology (AiIE) (2002) *Delivering the Landfill Directive: The Role of New and Emerging Technologies*. Report for the Strategy Unit 0008/2002

Associates in Industrial Ecology (AiIE) (2003) *Review of residual waste treatment technologies Report prepared on behalf of Kingston upon Hull City Council and East Riding of Yorkshire Council*  
[http://www.hullcc.gov.uk/wastemanagement/download/aiie\\_report.pdf](http://www.hullcc.gov.uk/wastemanagement/download/aiie_report.pdf)

Cal Recovery Europe Ltd, Edited by Papadimitriou, E. K. and Stentiford, E. I. (2004) *Proceedings of the 1st UK Conference and Exhibition on: Biodegradable and Residual Waste Management* ISBN: 0-9544708-1-8

CIWM (2002) *Biological Techniques in Solid Waste Management and Land Remediation*. IWM Business Services Ltd.

DEFRA (2004) Introductory Guide: Options for the Diversion of Biodegradable Municipal Waste From Landfill:  
<http://www.defra.gov.uk/environment/waste/wip/newtech/index.htm>

Procurement Toolkit  
<http://lasupport.defra.gov.uk/Default.aspx?Menu=Menu&Module=Article&ArticleID=102>.

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The Local Government PFI project support guide at [www.local.odpm.gov.uk/pfi/grantcond.pdf](http://www.local.odpm.gov.uk/pfi/grantcond.pdf).

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[http://reports.eea.eu.int/topic\\_report\\_2001\\_15/en](http://reports.eea.eu.int/topic_report_2001_15/en).

Eunomia Research & Consulting (2003) *Economic Analysis of Options for Managing Biodegradable Municipal Waste*. Available from the European Commission website:  
[http://europa.eu.int/comm/environment/waste/compost/econanalysis\\_finalreport.pdf](http://europa.eu.int/comm/environment/waste/compost/econanalysis_finalreport.pdf).



<b>Aerobic</b>	In the presence of oxygen.
<b>Aerobic Digestion/Composting</b>	Biological decomposition of organic materials by micro-organisms under controlled, aerobic, conditions to a relatively stable humus-like material called compost.
<b>Anaerobic</b>	In the absence of oxygen.
<b>Anaerobic Digestion</b>	A process where biodegradable material is encouraged to break down in the absence of oxygen. Material is placed in to an enclosed vessel and in controlled conditions the waste breaks down typically into a digestate, liquor and biogas.
<b>Animal By-Products Regulation</b>	Legislation governing the processing of wastes derived from animal sources.
<b>Auger</b>	Helical shaft, or shaft fitted with a screw-thread, designed to bore into and/or move material along its length.
<b>Baffle</b>	Rigid plate used to direct the flow of material.
<b>Biodegradable</b>	Capable of being degraded by plants and animals. Biodegradable municipal waste includes paper and card, food and garden waste, and a proportion of other wastes, such as textiles.
<b>Biogas</b>	Gas resulting from the fermentation of waste in the absence of air (methane/carbon dioxide).
<b>Biodegradable Municipal Waste (BMW)</b>	The component of Municipal Solid Waste capable of being degraded by plants and animals. Biodegradable Municipal Waste includes paper and card, food and garden waste, and a proportion of other wastes, such as textiles.
<b>Digestate</b>	Solid and/or liquid product resulting from Anaerobic Digestion.
<b>EPA 1990</b>	Environmental Protection Act.
<b>Feedstock</b>	Raw material required for a process.
<b>Greenhouse Gas</b>	A term given to those gas compounds in the atmosphere that reflect heat back toward earth rather than letting it escape freely into space. Several gases are involved, including carbon dioxide (CO <sub>2</sub> ), methane (CH <sub>4</sub> ), nitrous oxide (N <sub>2</sub> O), ozone, water vapour and some of the chlorofluorocarbons.
<b>Green Waste</b>	Vegetation and plant matter from household gardens, local authority parks and gardens and commercial landscaped gardens.
<b>Global Warming</b>	The progressive gradual rise of the earth's surface temperature thought to be caused by the greenhouse effect and responsible for changes in global climate patterns. An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases.

# Glossary

<b>In-vessel Composting</b>	The aerobic decomposition of shredded and mixed organic waste within an enclosed container, where the control systems for material degradation are fully automated. Moisture, temperature, and odour can be regulated, and stable compost can be produced much more quickly than outdoor windrow composting.
<b>Mechanical Biological Treatment (MBT)</b>	A generic term for mechanical sorting/separation technologies used in conjunction with biological treatment processes, such as composting.
<b>Municipal Solid Waste (MSW)</b>	Household waste and any other wastes collected by the Waste Collection Authority, or its agents, such as municipal parks and gardens waste, beach cleansing waste, commercial or industrial waste, and waste resulting from the clearance of fly-tipped materials.
<b>Recyclate/Recyclable Materials</b>	Post-use materials that can be recycled for the original purpose, or for different purposes.
<b>Recycling</b>	Involves the processing of wastes, into either the same product or a different one. Many non-hazardous wastes such as paper, glass, cardboard, plastics and scrap metals can be recycled. Hazardous wastes such as solvents can also be recycled by specialist companies.
<b>Refuse Derived Fuel (RDF)</b>	A fuel produced from combustible waste that can be stored and transported, or used directly on site to produce heat and/or power.
<b>Renewables Obligation</b>	Introduced in 2002 by the Department of Trade and Industry, this system creates a market in tradable renewable energy certificates, for which each supplier of electricity must demonstrate compliance with increasing Government targets for renewable energy generation.
<b>Source-segregated/ Source-separated</b>	Usually applies to household waste collection systems where recyclable and/or organic fractions of the waste stream are separated by the householder and are often collected separately.
<b>Statutory Best Value Performance Indicators (BVPI)</b>	Local Authorities submit performance data to Government in the form of annual performance indicators (PIs). The Recycling and Composting PIs have statutory targets attached to them which Authorities are required to meet.
<b>Tine</b>	Point, or spike protruding from a central shaft to agitate and break-up material during turning.



[www.defra.gov.uk](http://www.defra.gov.uk)



Waste Implementation Programme  
New Technologies