Advanced Biological Treatment of Municipal Solid Waste

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Department for Environment Food and Rural Affairs

Contents

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Preamble

This Waste Management Technology Brief, updated in 2007, is one of a series of documents prepared under the New Technologies work stream of the Defra Waste Implementation Programme. The Briefs address technologies that may have an increasing role in diverting Municipal Solid Waste (MSW) from landfill. They provide an alternative technical option as part of an integrated waste strategy, having the potential to recover materials & energy and reduce the quantity of MSW requiring final disposal to landfill. Other titles in this series include: An Introductory Guide to Waste Management Options, Mechanical Biological Treatment, Mechanical Heat Treatment; Advanced Thermal Treatment; Incineration, Renewable Energy and Waste Technologies, and Managing Outputs from Waste Technologies.

These waste technologies can assist in the delivery of the Government's key objectives, as outlined in The Waste Strategy for England 2007, for meeting and exceeding the Landfill Directive diversion targets, and increasing recycling of resources and recovery of energy.

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. It should be noted that these documents are intended as guides to each generic technology area. Further information can be found at the Waste Technology Data Centre, funded by the Defra New Technologies Programme and delivered by the Environment Agency (www.environment-agency.gov.uk/wtd). This brief deals with biological treatment technologies, which can be used to treat source segregated organic waste or mechanically separated organic waste. In the latter, ABT is a component of a Mechanical Biological Treatment (MBT) process, on which there is a separate Technology Brief. Information on the collection and markets for source segregated materials is available from Defra and from ROTATE (Recycling and Organics Technical Advisory Team) at the Waste & Resources Action Programme (WRAP).

The Defra New Technologies Demonstrator Programme has provided nine projects aimed at proving the economic, social and environmental viability (or not) of a selection of waste management technologies. For information on the demonstrator projects see the Defra website or email Wastetech@enviros.com.

1. 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. Historically, the quantity of MSW has risen year on year[1], presenting a growing problem for local authorities particularly as legislation, now limits (by implication[2]) the amount of mixed MSW that can be sent to landfill, becomes more stringent over time.

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 to landfill 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 62% of all MSW generated in England is disposed of in landfills[3]. However, European and UK legislation has been put in place to limit the amount of biodegradable municipal waste (BMW) sent for disposal in landfills[4]. The Landfill Directive also requires waste to be pre-treated prior to disposal. The diversion of this material is one of the most significant challenges facing the management of Municipal Solid Waste in the UK.

There are a wide variety of alternative waste management options for dealing with MSW 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 available referred to as Advanced Biological Treatment (ABT). These technologies include in-vessel composting and anaerobic digestion and are part of a range of processes currently being assessed and investigated through the New Technologies work stream of Defra's Waste Implementation Programme (WIP). Further information can be found on the Waste Technology Data Centre, funded by the Defra New Technologies Programme and delivered by the Environment Agency (www.environment-agency.gov.uk/wtd).

The role of ABT technologies, particulary anaerobic digestion (AD) was emphasised in the Waste Strategy for England 2007. ABT can be used to process source segregated waste to produce quality compost/digestate or it can be the biological component of Mechanical Biological Treatment (on which there is a separate Technology Brief). ABT still has a limited track record in the UK for treating the organic fraction of mixed, residual MSW. UK case studies are provided within this brief, including those from the Defra New Technologies Demonstrator Programme. The aim of this document is to raise awareness of these types of technologies and present the most current information regarding their implementation.

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1 This is now showing signs of slowing down and in some areas waste arisings are falling, and indeed in 2005/6 there was a 3% fall nationally. However, this may be partly explained by other factors occurring in that particular financial year
2 Targets pertain to the biodegradable fraction
3 Results from WasteDataFlow http://www.defra.gov.uk/environment/statistics/wastats/bulletin.htm
4 The Landfill Directive, Waste and Emissions Trading Act 2003 and Landfill Allowances Trading Scheme Regulations

2. How it works

2.1 Introduction

This Brief describes the biological treatment of biodegradable municipal waste. Some ABT technologies have already been used in the UK for source segregated waste, for green garden waste and food waste; and in other industries such as for sewage sludge treatment and in agriculture. ABT processes can also be used to treat the biodegradable fraction mechanically separated from mixed, residual MSW at a Mechanical Biological Treatment (MBT) facility, although it still has a limited track record in the UK.

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 the Waste Technology Data Centre. Other relevant sources of information are identified throughout the document.

2.2 The Process

ABT technologies are designed and engineered to control and enhance natural biological processes, and as such can only act on biodegradable organic materials. ABT processes can treat either source segregated materials or those mechanically separated from a mixed waste stream into a biodegradable, organic rich fraction.

Source segregated collections will provide a cleaner organic stream, but on their own are unlikely to capture sufficient organic material to achieve the required level of Biodegradable Municipal Waste (BMW) diversion from landfill. Therefore, additional diversion of BMW will be required through processes such as MBT or thermal treatment technologies in the longterm.

In line with the EU Landfill Directive and national recycling targets, the function of ABT facilities includes the:

- Diversion from landfill through the production of compost (or a digestate) that can be safely applied to agricultural land for ecological benefit[5];
- Pre-treatment of waste going to landfill, to reduce its biodegradability, if unsuitable for application to land;
- Diversion of biodegradable MSW going to landfill if using ABT within an MBT by:
  - Reducing the dry mass of BMW prior to landfill;
  - Reducing the biodegradability of BMW prior to landfill;
  - Stabilisation into a compost-like output (CLO)[6] for potential use on land (although markets likely to be limited where mixed waste is the source);
  - Deriving a combustible biogas from the organic waste for energy recovery; and/or
  - Drying materials to produce a high calorific organic fraction for use as a fuel (Refuse derived fuel RDF).

2.3 Advanced biological treatment (ABT) Options

Advanced biological treatment is concerned with the use of relatively new technologies to treat biodegradable wastes using tightly controlled biological processes. Food and green wastes are suitable input materials for these technologies. Other biodegradable material, such as card, paper and wood can be treated, however they take a longer time to degrade and input levels are limited to optimise the processing.

5 Compost that has been produced from source segregated waste is currently only allowed to be applied to agricultural land
6 Compost-like Output (CLO) is also sometimes referred to as 'stabilised biowaste' or a soil conditioner; it is not the same as a source-segregated waste derived 'compost' or 'soil improver' that will contain much less contamination and has a wider range of end uses

2. How it works

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

Microbes excrete specialised enzymes that digest biodegradable waste constituents (e.g. cellulose and other complex polysaccharides, proteins and fats) into simple nutrients (e.g. sugars, amino acids, fatty acids), which they absorb. As the microbes grow and proliferate a significant proportion of this is converted into heat, carbon gases and water, which can result in large losses in mass during biological treatment.

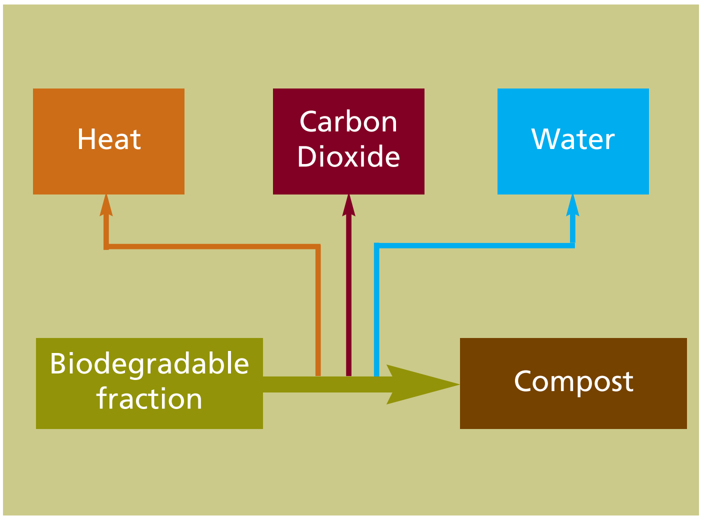
There are two main types of conditions in which such microbes live, and therefore two main classes of biological processes used to treat biodegradable waste:

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

Aerobic composting processes

During aerobic decomposition, biodegradable material is decomposed into carbon dioxide (CO_2), water (H_20), and heat through microbial respiration in the presence of oxygen (Figure 1) leaving a stabilised residual solid material, compost[7]. If source segregated biodegradable material is treated, oxygen is often supplied passively through the presence of air or through mechanical turning. In MBT systems, air is usually blown or drawn through material, to speed up the drying and/or decomposition of the material.

Figure 1: Aerobic Decomposition



Aerobic processes are relatively dry and used for materials with high solids content (a moisture content of around 60% is considered optimal). These materials must have a good porous physical structure to allow the air to pass through the material. The right balance of carbon to nitrogen (and other mineral nutrients) is also required.

Accelerated aerobic processes require a net input of energy to supply the oxygen required. A large amount of biologically produced heat is created as microbes respire, and are associated with high processing temperatures of 60 – 70°C. High temperatures have the advantage of killing potentially pathogenic organisms in the waste (sanitisation), and can also be used to dry material.

As the process progresses biodegradable material is converted into carbon dioxide, water, and heat, which are lost to the atmosphere. The material remaining consists

[7] Stabilised is the degree of processing and biodegradation at which a) the rate of biological activity under favourable aerobic biodegradation has slowed ; b) microbial respiration will not revive significantly until environmental conditions are altered

of a mixture of non-biodegradable materials; recalcitrant organics; microbes and microbial remains; and a complex of decomposition by-products called humus. This stabilised and dried mixture is known as compost.

Anaerobic digestion (biogas) processes

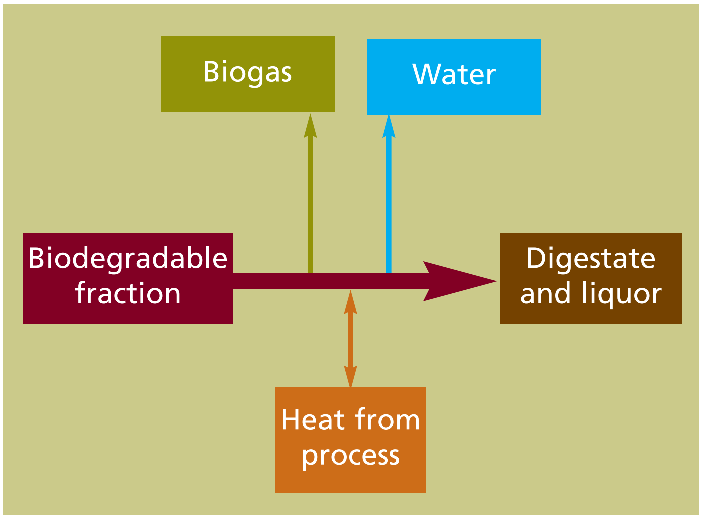
During anaerobic digestion (AD) biodegradable material is converted into methane (CH_4) and carbon dioxide (together known as biogas), and water, through microbial fermentation in the absence of oxygen (Figure 2), leaving a partially stabilised wet organic mixture.

AD is ether a 'wet' process used for materials with moisture contents more than ?85% or a 'dry' process used for materials with moisture contents ?80%. Anaerobic processes require less energy input than aerobic composting and create much lower amounts of biologically produced heat. Additional heat may be required to maintain optimal temperatures but the biogas produced contains more energy than is required i.e. the process is a net producer of energy.

As the process progresses biodegradable material is converted into a combustible gas known as 'biogas' primarily consisting of a mixture of methane and carbon dioxide. Biogas can be burned for heat and/or electricity production. The material remaining consists of a wet solid or liquid suspension of non-biodegradable materials; recalcitrant organics; microbes (biomass) and microbial remains; and decomposition by-products. This partially stabilised wet mixture is known as 'digestate'.

This wet mixture can be dewatered into its solid and liquid fractions. Sometimes these 2 fractions may both be referred to as 'digestate', but for clarity they will be referred to as digestate and liquor in this publication.

Figure 2: Anaerobic Digestion



2.4 Aerobic (composting) technologies

Aerobic treatment (composting) technologies come in a range of designs. All systems are designed and engineered to control and optimise the biological stabilisation, sanitisation, and/or, in some cases, drying of biodegradable materials.

These processes can last anywhere from a few days to 8 or more weeks depending on the degree to which the material is to be stabilised. For example, when the purpose of the process is to dry material prior to mechanical separation in an MBT facility, the process can be very short. If material is being stabilised prior to its use as compost, compost-like-output or disposal to landfill, a number of weeks processing will be required.

The technologies described here are all enclosed, either in buildings and/or specifically designed vessels (e.g. tunnels, drums, or towers) and are typically known as in-vessel composting (IVC). The techniques used to control the supply of oxygen required by the process are the mechanical agitation

2. How it works

of waste (turning) and/or blowing or sucking air through the waste (forced aeration) offering differing levels of process control and automation. Two methods of material flow are offered: batch or continuous input (see Table 1).

Table 1: Technology Options

System	Material Flow	Aeration Method
Tunnels	Batch	Forced aeration
		Forced aeration and mechanical agitation
	Continuous	Forced aeration
		Forced aeration and mechanical agitation
Vertical towers/silos	Continuous	Passive aeration
		Forced aeration
		Forced aeration and mechanical agitation
Rotating drums	Continuous	Mechanical agitation
		Forced aeration and mechanical agitation
Housed bays, piles or extended-beds	Batch	Mechanical agitation
		Forced aeration, mechanical agitation
	Continuous	Mechanical agitation
		Forced aeration, mechanical agitation

Tunnels

Tunnel composting units are large-scale rectangular vessels employing forced aeration systems. They can be built as permanent structures constructed from concrete and steel, or more temporary 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 mechanical systems such as moving floors, rotating shafts, and augers, to move the material through the tunnel. Tunnels can be filled manually using wheeled loading shovels or using specialised filling equipment, such as conveyors.

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

Moisture may be controlled by pumping process water 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 undergone the required processing time, it is removed from the bottom on the vessel (or compartment) using augers or scraping arms.

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

Agitated bays, piles and extended-beds

Organic material is fed into a large enclosed building for processing. The material is either placed in long concrete-walled bays, piles (windrows), 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 can also be used, consisting of large bucket-wheels or augers suspended from mobile gantries in the roof of the processing building.

During the turning process material can be moved along the length of a bay or processing building in a continuous flow fashion. In some cases, these systems are operated as a batch process.

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 as well as improving working conditions inside the building.

Rotating drums

This is usually a continuous process, where material is fed into a large, rotating drum. The material is mixed and aerated as it passes along the drum. Material is agitated 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, reduce waste particle sizes, and dry waste materials. They can be used in this way as a pre-treatment alternative to waste shredding, to aid mechanical sorting. They can also be used to stabilise and sanitise pre-sorted waste.

Bio-drying

When the composting technologies described above are used to dry 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'. The concept of bio-drying is to force air through the hot biologically active waste to dry it quickly. Drying makes the waste more amenable to mechanical separation and increases its calorific value if used as a fuel. This also reduces the mass of waste and partially reduces its biodegradable content. Some energy is consumed in drying the material and negates to some extent the energy gained through drying the waste.

2.5 Anaerobic digestion (biogas) technologies

Anaerobic digestion (AD), also known as biogas technologies, are designed and engineered to control and optimise the

2. How it works

biological digestion of biodegradable materials to produce methane gas for energy production. The technologies are, by their nature, enclosed, using specifically designed vertical and/or horizontal vessels, interconnecting pipe-work, mixers, macerators and pumps.

AD processes last around two to three weeks depending on the ease and degree to which materials are converted into biogas and the technology used. For example, for waste containing a larger amount of woody (high lignin content) material, longer residence times will be required to achieve the desired biogas production.

There are two main classifications of AD techniques: 'wet' and 'dry' (Table 2). In essence, 'wet' AD systems process more liquid materials (?85% moisture), whereas 'dry' AD processes are used to treat drier materials (?80% moisture) ranging from thick slurry to a wet solid. Waste feedstock is mixed and macerated with a large proportion of process effluent and/or fresh water to prepare the waste; giving it the moisture and flow properties required.

Table 2: AD (biogas) Technology options

Wet or Dry	Operating Temperature	Process Stages
Wet (low solids)	Mesophilic	Single
		Multiple
	Thermophilic	Single
		Multiple
Dry (high solids)	Mesophilic	Single
		Multiple
	Thermophilic	Single
		Multiple

'Wet' AD technology

'Wet' AD systems used to treat municipal solid waste have been adapted from well established systems used to treat wastewater treatment plant biosolids. The digestion process takes place in sealed vertical tanks (digesters) that are usually continuously mixed to maximise contact between microbes and waste. Mixing can be achieved using mechanical stirring devices, or by recirculating biogas or waste through the digestion tank. Transfer of material between several tanks is achieved through pumps. This type of wet system is better suited to feedstocks that are readily converted to liquid e.g. food wastes.

In some 'wet' AD systems the waste preparation stage can be used to decontaminate mixed residual MSW by removing heavy and light contaminants through wet gravimetric separation.

'Dry' AD technology

'Dry' systems use plug flow reactor designs. This approach involves adding fresh waste and/or partially fermented waste into one end of the reactor while fully digested residue is extracted from the other. Dry technologies can comprise vertical or horizontal tanks. Vertical tanks rely on gravity to move material through the system, whereas horizontal systems use specialised augers or baffles. A potential advantage of the dry system is that it can tolerate higher levels of physical contaminants.

Operating temperatures

AD technologies can be operated at moderate (mesophilic: 30 – 40°C) temperatures or high (thermophilic: 50 – 60°C) temperatures. 'Dry' AD processes lend themselves to thermophilic operation due to higher solids content and greater biological heat production. 'Wet' AD processes can be operated at either temperature, but are most commonly mesophilic. In mesophilic systems, a pasteurisation unit is used to heat the material before or after digestion to achieve sanitization.

Single step and multiple step processes

AD processes can be single step processes where all the waste is placed into a single digestion stage/vessel, or a multiple step process using vessels to optimise different stages of the process. Multiple step processes often involve a separate hydrolysis stage, which can be aerobic or anaerobic, to breakdown complex organic material into soluble compounds. This is followed by a high-rate biogas production stage.

Some case study examples are described in Section 4, and further information on these and additional specific examples can be obtained from the Waste Technology Data Centre.

Biogas

Biogas produced during anaerobic digestion is primarily composed of methane (typically ranging between 50 – 75%) and carbon dioxide, as well as smaller quantities of other gases including hydrogen sulphide. Biogas is also water saturated (100% humidity).

The amount of biogas produced using AD will vary depending on the process design, such as retention times and operation temperature, and the volatile solids (organic matter) content of the feedstock, i.e. the composition of the waste inputs.

Biogas is stored in large vessels prior to its use on or off site. Biogas can be used in a number of ways (see Section 3.3), but is usually burned to produce heat and electricity using some form of generator. Some electricity is used by the plant, but any excess electricity produced can be sold and exported via the local electricity distribution network. Excess heat can also be used locally, in a district heating scheme or by a neighbouring commercial or industrial facility.

Digestate and liquor

Due to the high moisture content of the waste material entering the process, and the breakdown of solids during digestion, digestate can have a high moisture content upon leaving the process. The material produced is kept in a storage tank and can be mechanically pressed into its solids (digestate) and liquid (liquor) fractions.

The dewatered digestate may be used directly on land as a soil amendment provided it meets appropriate regulatory standards (see Section 3), or aerobically treated to produce a compost (if from source segregated material) or a compost-like output (if from mechanically separated material). Some liquor may be recycled in the AD process to wet incoming waste; used directly on land as a liquid fertilizer due to its valuable nitrogen content (provided it meets appropriate regulatory criteria); or used to maintain moisture during the aerobic treatment of the digestate. Alternatively, if no other route is available, the liquor may be treated and discharged in accordance with permit requirements.

2.8 Energy balance benefits and feedstock issues

Although IVC and AD treat similar wastes, they are in fact complimentary and not competing technologies. From an energy consumption and greenhouse gas emission reduction point of view, there is merit in having an AD stage first following by composting. The benefit of an AD process is that it produces energy in the form of biogas, whereas IVC will generally use energy in the processing stages, in aerating the waste and treating any leachate arising from the process. Although AD liquor often needs treating, the energy required is available from the biogas. The digestate from AD often needs to be matured by composting before it can be applied to land. Since the AD process has reduced the total amount of material, less energy should be required than if the whole amount of waste was treated through IVC. Notwithstanding these issues, some proportions of materials are inherently better suited to either composting of anaerobic digestion. For example, high proportions of green waste with much bulky wood material is better suited to composting processes as it is easier to handle and has less gas production. Conversely, high proportions of kitchen waste are better suited to AD processes as the gas production potential is higher and odour control is easier to achieve.

3. Markets and outlets for the outputs

3.1 Introduction

The markets and outlets discussed in this section relate primarily to those produced from the biological treatment of source segregated municipal waste. ABT has the potential to produce a number of useful outputs including compost from aerobic composting and digestate, liquor and biogas from anaerobic digestion. Outlets for the outputs from ABT treating mixed, residual MSW are discussed in more detail in the MBT Brief.

3.2 Use of compost on land

ABT processing of source segregated organic municipal waste can produce stabilised and sanitised compost or partially stabilised digestate material. The potential applications of these outputs are dependent upon their quality and legislative and market conditions.

The quality of compost produced will vary with different ABT technologies, the quality of raw waste inputs (including seasonal variations), and the method and intensity of waste preparation and separation prior to ABT, as well as the methods used to screen the outputs. Compost is suitable for use in a number of sectors, including:

- Land restoration and soft landscaping
- Domestic use in gardens
- Agriculture and horticulture

The activities of the Waste & Resources Action Programme (WRAP) have resulted in the development by the British Standards Institute of a Publicly Available Specification for composted materials (BSI PAS 100). The purpose of the specification is to increase consumer confidence in buying compost. Compost producers who are PAS 100 certified produce a 'quality compost', by processing source segregated biodegradable waste which does not exceed the limits illustrated in Table 3. For more information see the WRAP website http://www.wrap.org.uk/composting/compost_specifications/index.html

Table 3: BSI PAS 100 criteria*

Parameter	BSI PAS 100 limit
Cadmium, ppm	1.5
Chromium, ppm	100
Copper, ppm	200
Mercury, ppm	1
Nickel, ppm	50
Lead, ppm	200
Zinc, ppm	400
Impurities >2mm	0.5%; of which 0.25% maximum can be plastic
Gravel & stones	>4mm <8% in grades other than coarse mulch; >4mm in coarse mulch grade <16%
Pathogens	E.coli 1000 cfu/g; No Salmonella in 25g
Microbial respiration rate	16 mg CO_2/g organic matter/day

* BSI PAS 100 is only valid for composts derived from source-segregated waste, by definition

Compost derived from waste will only cease to be a waste when it is applied to land under an exemption from the Environment Agency. This is considered to be a barrier to increasing compost use. In order to formalise a quality control procedure for using compost produced from source segregated waste, a Quality Protocol has been developed[8].

8 The Quality Protocol for the production and use of quality compost from source-segregated biowaste, developed by the Business Resource Efficiency and Waste (BREW) programme, WRAP and the Environment Agency, published March 2007

3. Markets and outlets for the outputs

The Quality Protocol for Compost developed by WRAP, the Environment Agency and other key players in the industry sector, sets out the criteria for the production of quality compost from source segregated biowaste like food and garden waste. If compost is produced according to these criteria the compost produced is no longer regarded as a waste and can be spread to land without the need to register with the Environment Agency for a waste exemption. Compost not produced according to the protocol is still considered to be waste, including any output from non-certified composting sites (e.g. sites which are not PAS 100 certified or sites covered by other acceptable certification schemes).

Digestate and liquor are both sources of nutrients, particularly nitrogen, which offer great potential for energy and emissions savings compared with artificially manufactured fertiliser. WRAP and partner organisations are producing a Protocol for digestate from AD that will function in a similar way to the Composting Protocol to ease the regulatory barriers to using the outputs from AD. It is expected to be finalised in mid 2008.

Due to its low quality, opportunities to apply compost-like outputs (CLO) and digestate produced from mixed MSW to land will be limited (see MBT technology brief).

Waste Management Licensing Regulations

Changes to the Waste Management Licensing Regulations came into force on 1st July 2005[9]. Unless the Quality Protocol applies, a waste management licence (WML) exemption, under Paragraph 7A of the regulations, is required by land owners/managers before any compost, digestate or liquor derived from source-segregated waste materials can be applied to agricultural land. A compost-like output, derived from mixed residual waste, is not allowed to be applied to agricultural land. These outputs may be applied to brownfield and restoration land under a WML exemption, under Paragraph 9A, provided that ecological benefit is demonstrated.

The Government and the National Assembly for Wales consulted in May 2006 on the requirement for compost or digestate to be derived from source-segregated materials if it is to be permitted to be spread to agricultural land, under a Paragraph 7A WML Exemption. In the light of consultation, the Government has concluded that, for now, the source-segregation requirement should remain. However, the Government views this as an interim measure, and will carry out work to find a longer term, more sustainable solution that will encourage the development of [mixed MSW ABT] technologies that will produce high standard outputs which could be safely spread to land.

For the latest position contact or visit the Environment Agency and Defra websites.

Animal By-Products Regulations (ABPR)

ABT plants that process food waste and 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 treatment and hygiene standards required by source-segregated waste composting/biogas plants (see Section 6).

Mixed MSW will contain household kitchen ('catering') waste including meat, and as such will, at least, fall under UK national ABPR[10]

[9] The Waste Management Licensing (England and Wales) (Amendment and Related Provisions) (No. 3) Regulations 2005 (S.I. No. 1728)
[10] Animal By-products Regulations 2003 (SI 2003/1482); Wales (SI 2003/2756 W.267); Scotland (SSI 2003/411)

3. Markets and outlets for the outputs

standards for catering waste containing meat. In some cases it may also contain certain commercial/industrial waste containing raw meat or fish; classified as 'Category 3' animal by-products. Category 3 animal by-products must be treated in accordance with the EU regulation[11] standards.

3.3 Biogas from anaerobic digestion

Biogas can be used in a number of ways. It can be used as a natural gas substitute (distributed into the natural gas supply) or converted into fuel for use in vehicles. More commonly it is used to fuel boilers to produce heat (hot water and steam), or to fuel generators in combined heat and power (CHP) applications to generate electricity, as well as heat.

Biogas electricity production per tonne of waste can range from 75 to 225 kWh, varying according to the feedstock composition, biogas production rates and electrical generation equipment. Generating electricity from biogas is considered 'renewable energy' and benefits from support under the Renewables Obligation, see Section 9.3.

In most simple energy production applications, only a little biogas pre-treatment is required. Biogas used in a boiler requires minimal treatment and compression, as boilers are much less sensitive to hydrogen sulphide and moisture levels, and can operate at a much lower input gas pressure.

Where biogas is used for onsite electricity generation, a generator similar to that used in landfill gas applications can be used, as these generators are designed to combust moist gas containing some hydrogen sulphide. Gas compression equipment may be required to boost the gas pressure to the level required by the generator.

Some electricity is used by the AD plant, but excess electricity produced (typically ~75%) can be sold and exported via the local electricity distribution network. Excess heat can also be used locally in a district heating scheme, if there is an available user.

For high specification applications (e.g. vehicle fuel, natural gas substitute), or when using more sophisticated electricity generation equipment (e.g. turbines), biogas will require more pre-treatment to upgrade its quality. This includes the removal of hydrogen sulphide (a corrosive gas); moisture removal; pressurization to boost gas pressure; and removing carbon dioxide to increase the calorific value of the biogas. However, the cost of the equipment required to upgrade biogas can be prohibitive.

3.4 Refuse Derived Fuel (RDF)

RDF is not usually an output from ABT accepting source segregated waste only. For information on RDF outlets please refer to the MBT Technology Brief.

11 Regulation EC 1774/2002 laying down health rules concerning animal by-products not intended for human consumption

4. Track record

ABT technologies such as in-vessel composting (IVC) and anaerobic digestion have been proven for source segregated materials overseas and increasingly in the UK, but operations processing organics from MBT are much fewer. The examples illustrated here are for UK facilities, including two from the Defra New Technologies Demonstrator Programme. For examples of facilities using ABT within MBT processing mixed residual MSW, please see the separate MBT Brief within this series.

4.1 Aerobic (composting) technology

This form of technology has been commercially developed in the UK for source-segregated materials. Most UK experience to date is still dominated by open-air mechanically turned pile (windrow) composting accepting green garden waste, although in-vessel facilities have increased due to the Animal By-Product Regulations. In-vessel systems allow animal by-products, such as meat and dairy products, to be composted.

Case studies

Bioganix rotating drum in-vessel compost facility, Parham near Ipswich

This £2.4 million rotating drum composting system is designed to take 15,000 tonnes per year, including source-segregated garden and kitchen waste from Suffolk Coastal District Council. The waste is shredded before it is placed inside the rotating drum. It is a batch process, so once a drum has been filled the process begins. The material is composted in one drum for 4 days. The material is then removed from the drum, screened to a 12mm particle size and placed into a second drum supplemented with steam to achieve sanitisation under EU animal by-products legislation. This material is then distributed off-site for use on farmland.

A new Bioganix facility has recently been constructed under the Defra New Technologies Demonstrator Programme in Leominster. The facility accepts source segregated organic waste from Shropshire and Herefordshire. A visitor centre will be available for local authorities to learn more about the Bioganix process.

Terra Eco Systems in-vessel composting system, High Heavens, High Wycombe, Buckinghamshire

High Heavens IVC composting bays. Source: CRS
www.crservices.co.uk

The High Heavens facility was built to a CRS Ltd design and is operated by Terra Eco Systems for Buckinghamshire County Council. Partial funding was received from the Defra Challenge fund. The facility has been operating under full ABPR approval since February 2005 and receives kerbside collected garden and kitchen waste, also garden waste from civic amenity facilities. Current process capacity is for 15,000 tonnes per year; a planned expansion to 40,000 tonnes per year will accommodate increased kerbside collections.

Input material is shredded, has water added and is then screened (200 mm) before being loaded into a first barrier composting bay. The composting process takes place in single door bays, each having a capacity of around 140 tonnes. Aerobic conditions are sustained through use of an air handling system, with air being drawn into the compost from pipes within the floor and then either recirculated or vented through an odour control system.

4. Track record

Continuous temperature monitoring identifies the stage at which the first ABPR barrier has been passed, following which the material is moved to another composting bay and monitored until the second barrier is passed. The processed material can then be moved to an open maturation area. The composted material is distributed off site for use on farmland and in landscaping.

4.2 Anaerobic Digestion (biogas) technology

This technology has been proven on sewage sludge across the UK water industry, with some success on source segregated municipal waste.

South Shropshire Biowaste Digester (Greenfinch Ltd & South Shropshire District Council)

Greenfinch AD plant Ludlow. Photo: Greenfinch

This facility in Ludlow, Shropshire is a Defra New Technologies Demonstrator plant. It is designed to treat 5,000 tonnes per year of source separated garden and kitchen waste. The input waste undergoes two shredding/wetting stages before being placed into a feedstock buffer tank. This feeds the AD tank, which uses a uses wet mesophilic (37°C) AD process in a fully-mixed tank. The AD process is continuous with a batch pasteurisation process (70°C for one hour) at the end to meet ABPR requirements. The digested material is then separated into digestate (>0.5mm) for use as a soil conditioner, and liquor to be used as a biofertiliser. The biogas produced fuels a combined heat and power (CHP) unit, to produce renewable electricity for the grid and process heat available for district / local heat needs. When operating at full capacity, the net electricity production is estimated to be 1.5 million kWh and a net heat output of 2.2 million kWh.

Stornaway AD facility, Western Isles Scotland

Stornoway digestor under construction.
Source: Earth Tech UK

This facility is a 'dry' AD system by technology supplier Linde, constructed by Earth Tech. The source segregated organic stream is offloaded to a dedicated reception bay and then crushed to reduce particle size. Crushed waste is conveyed via an over band magnet to remove metal contamination before being screened through a trommel; the screened under size (<60 mm) is transferred to the anaerobic digestion plant and the over size is recycled back to the crusher. The screened material passes to aerated buffer tanks for 1.5 days to increase feedstock temperature prior to digestion and is further refined in particle size to comply with ABPR requirements (<50mm). The feed stock is then fed into the digester where it is anaerobically treated over a 26 day period.

4. Track record

The AD plant inputs are dry solids of approximately 32%, output dry solids of approximately 25%. The digester complies with ABPR requirements of 57°C for 5 hours.

Digestate is dewatered in a two stage system and the digestate cakes are taken off site for open windrow composting and maturation. Collected biogas is used to generate electricity and heat in a combined heat and power engine. All electricity produced qualifies for ROCs and is used to run the facility, with excess being exported to the grid.

4.3 MBT technology

Several MBT technologies have 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, with the construction of 2 plants operated by Shanks in East London Waste Authority (ELWA), the Biffa plant in operation in Leicester, the SITA plant in operation at Byker and the smaller scale Premier plant in County Durham.

The least proven aspect of MBT technologies is probably the final quality and contamination levels of any stabilised organic residues produced. There are expected to be only limited outlets for these compost-like outputs (CLOs), even when distributed free of charge, with costs involved to dispose of such materials through other routes. Further information is available in the MBT Technology Brief and other reference documents such as the SITA Environmental Trust report on MBT (see further reading).

5. Contractual and financing issues

5.1 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 'prudential' system of capital finance controls;

PFI Credits and Private Sector Financing: under the Private Finance Initiative a waste authority can obtain grant funding from central Government to support the capital expenditure required to deliver new facilities. This grant has the effect of reducing the financing costs for the Private Sector, thereby reducing the charge for the treatment service;

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 capacity for this will be limited but generally it is through raising taxes.

The Government is encouraging the use of different funding streams, otherwise known as a 'mixed economy' for the financing and procurement of new waste infrastructure to reflect the varying needs of local authorities.

Contractual Arrangements

Medium and large scale municipal waste management contracts are usually procured through the Competitive Dialogue procedure under the Public Contract Regulations (2006).

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 grant funding from Government as a supplement to finance from its own and private sector sources. The PFI grant is only eligible for facilities treating residual waste and is payable once capital expenditure is incurred.

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) are currently seeking 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.

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 the following sources:

- Local Authority funding http://www.defra.gov.uk/environment/waste/localauth/funding/pfi/index.htm

- The Local Government PFI project support guide www.local.odpm.gov.uk/pfi/grantcond.pdf

- For Works Contracts: the Institution of Civil Engineers 'New Engineering Contract' (available at www.ice.org.uk)

- For large scale Waste Services Contracts through PFI and guidance on waste sector projects see the 4ps, local government's project delivery organisation http://www.4ps.gov.uk/PageContent.aspx?id=90&tp=Y

6. Planning and permitting issues

6.1 Planning

This section contains information on the planning and regulatory issues associated with ABT facilities based on legislative requirements, formal guidance, good practice and in particular drawing on information contained in the Office of the Deputy Prime Minister's research report on waste planning published in August 2004[12].

6.2 Planning

All development activities are covered by Planning laws and regulations. Minor development may be allowed under Permitted Development rights but in almost all cases new development proposals for waste facilities will require planning permission.

Under certain circumstances new waste facilities can be developed on sites previously used for General Industrial (B2) or Storage and Distribution (B8) activities. In practice even where existing buildings are to be used to accommodate new waste processes, variations to existing permissions are likely to be required to reflect changes in traffic movements, emissions etc.

Under changes to the planning system introduced in 2006 all waste development is now classed as 'Major Development'. This has implications with respect to the level of information that the planning authority will expect to accompany the application and also with respect to the likely planning determination period. The target determination periods for different applications are:

- Standard Application – 8 weeks
- Major Development - 13 weeks
- EIA Development - 16 weeks

The principal national planning policy objectives associated with waste management activities are set out in Planning Policy Statement (PPS) 10 'Planning for Sustainable Waste Management' published in July 2005. Supplementary guidance is also contained within the Companion Guide to PPS 10. Both of these documents can be accessed via the Department of Communities and Local Government (DCLG) website[13].

PPS 10 places the emphasis on the plan led system which should facilitate the development of new waste facilities through the identification of sites and policies in the relevant local development plan. Separate guidance on the content and validation of planning applications is also available from DCLG through their website[14]. Individual Planning Authorities can set out their own requirements with respect to supporting information and design criteria through Supplementary Planning Documents linked to the Local Development Framework. It is important that prospective developers liaise closely with their Local Planning Authorities over the content and scope of planning applications.

The process of gaining planning permission for a new ABT facility should not be underestimated. Although potentially less contentious compared with other waste processing operations such as thermal treatment the majority of all new waste proposals attract considerable local interest.

12 http://www.communities.gov.uk/embeddedindex.asp?id=1145711
13 http://www.communities.gov.uk/index.asp?id=1143834
14 http://www.communities.gov.uk/pub/494/BestPracticeGuidanceontheValidationofPlanningApplicationsPDF326Kb_id1144494.pdf

6. Planning and permitting issues

6.3 Key Issues

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.

When considering the planning implications of an ABT facility the other issues that will need to be considered are common to most waste management facilities. The key issues are therefore:

- Plant/Facility Siting;
- Traffic;
- Air Emissions / Health Effects;
- Odour;
- Bio-aerosols (and Dust)
- Flies, Vermin and Birds;
- Noise;
- Litter;
- Water Resources;
- Nutrient Retention; and
- Visual Intrusion.

A brief overview of the planning context for each of these issues is provided below.

6.4 Plant Siting

ABT technologies are often housed in purpose designed and configured buildings but may also, (particularly in-vessel composting) be developed within existing buildings. AD reactors are invariably externally sited tank structures.

PPS 10 and its Companion Guide contain general guidance on the selection of sites suitable for waste facilities. This guidance does not differentiate between facility types but states that:

"Most waste management activities are now suitable for industrial locations, many fall within the general industrial class in the Use Classes Order.[15]

The move towards facilities and processes being enclosed within purpose designed buildings, rather than in the open air, has accentuated this trend. The guidance goes on to state:

"With advancement in mitigation techniques, some waste facilities may also be considered as light industrial in nature and therefore compatible with residential development. In more rural areas, redundant agricultural and forestry buildings may also provide suitable opportunities, particularly for the management of agricultural wastes"

The following general criteria would also apply to the siting of new ABT plants:

- Buildings which might house ABT can be similar in appearance and characteristics to various process industries. It would often be suitable to locate facilities on land previously used for general industrial activities or land allocated in development plans for such (B2) uses;
- Facilities are likely to require good transport infrastructure. Such sites should either be located close to the primary road network or alternatively have the potential to be accessed by rail or barge;
- The location of such plants together with other waste operations such as MBT/MHT and ATTs can be advantageous. The potential for co-location of such facilities on resource recovery parks or similar is also

[15] The Town and Country Planning (Use Classes) Order 1987. SI 1987 No. 764

highlighted in the PPS 10 and the Companion Guide; and

- The potential for export of energy to host users or the national grid should also be a key consideration in the siting of AD type ABT plants.

6.5 Traffic

ABT facilities may be served by significant numbers of HGVs (depending on the scale of the facility) with a potential impact on local roads and the amenity of local residents. It is likely that the site layout/road configuration will need to be suitable to accept a range of light and heavy vehicles. For a 50,000tpa capacity plant, up to 20 Refuse Collection Vehicles per day would be anticipated.

6.6 Air Emissions / Health Effects

Potential health effects of composting facilities are likely to be strongly dependent on the type of facility (open windrow or in-vessel system). Studies have found no increase in cancer or asthma in populations close to composting facilities. However, even a well-run open windrow facility can give rise to emissions of micro-organisms and dusts, which can lead to public concern about health impacts on people living in close proximity to the facility. The Environment Agency suggests that risk assessments may be undertaken on sites where there are sensitive receptors nearby. Emissions and potential risks to health can be more readily controlled in an IVC and AD facility than an open site.

One published study has indicated a possible link between commercial scale open composting and respiratory symptoms in people living nearby. This study related to a single facility and is currently being re-evaluated by the German Environment Ministry.

No studies suggesting adverse health effects of AD facilities processing municipal waste have been published. Depending on the nature of an individual facility, potential health effects of AD facilities might be expected to be comparable to those of composting facilities, and may potentially have fewer emissions of volatile odorous compounds. AD processes also involve the production and combustion of biogas. This is beneficial for the production of heat and/or electricity, the combustion of biogas will result in mainly carbon dioxide and water vapour.

6.7 Odour

The control of odour at ABT facilities needs extremely careful consideration. As most ABT technologies are almost entirely enclosed, potential odour emissions can normally be controlled through the building ventilation system. If there is a combustion element to the facility, odorous air extracted from process areas can be used in the combustion stage. Particular attention may need to be paid to headspace air in enclosed storage facilities such as digestate tanks.

If there is no combustion element, the process of air extraction and ventilation will nevertheless dilute odorous air. It may be necessary to disperse extracted air from an elevated point, and/or treat the air. Biofiltration systems can be used for control of odours in air extracted from working areas if required. The need for, and design of odour control systems would need to be assessed on a site-by-site basis.

Control of odours from open composting systems relies on good control and management of the composting process. Some odour is unavoidable, and open composting facilities can be problematic from the perspective of odour if not properly sited and operated.

6. Planning and permitting issues

6.8 Flies, Vermin and Birds

The enclosed nature of ABT operations will limit the potential to attract vermin and birds. However, during hot weather it is possible that flies could accumulate, especially if they have been brought in during delivery of the waste. Effective housekeeping and on site management of tipping and storage areas is essential to minimise the risk from vermin and other pests. In some operations waste heat from the process may be used to bring temperatures in fresh input waste to levels above which flies can live.

6.9 Noise

Noise is an issue that will be controlled under the waste licensing regulations and noise levels received at nearby receptors can be limited by a condition of a planning permission. The main contributors to noise associated with ABT are likely to be:

- vehicle movements / manoeuvring;
- traffic noise on the local road networks;
- mechanical processing such as waste preparation;
- air extraction fans and ventilation systems; and
- operations associated with turning and aeration of the biomass.

6.10 Litter

Any waste which contains plastics and paper is more likely to lead to litter problems. Litter problems can be minimised as long as good working practices are adhered to and vehicles use covers and reception and processing are undertaken indoors.

6.11 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.

6.12 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.

6.13 Design Principles and Visual Intrusion

Planning guidance in PPS 10 emphasises the importance of good design in new waste facilities. Good design principles and architect input to the design and physical appearance of waste facilitates is essential. Buildings should be of an intrinsically high standard and should not need to be screened in most cases.

Good design principles also extend to other aspects of the facility including having regard to issues such as:

- Site access and layout;
- Energy efficiency;
- Water efficiency; and
- The general sustainability profile of the facility.

6. Planning and permitting issues

Construction of any building will have an effect on the visual landscape of an area. Visual intrusion issues should be dealt with on a site specific basis and the following items should be considered:

- Direct effect on landscape by removal of items such as trees or undertaking major earthworks;
- Site setting; is the site close to listed buildings, conservation areas or sensitive viewpoints;
- Existing large buildings and structures in the area;
- The potential of a stack associated with some air clean up systems for mixed waste processing operations may impact on visual intrusion;
- Use of screening features (trees, hedges, banks etc);
- The number of vehicles accessing the site and their frequency, and;
- Many of these facilities are housed in 'warehouse' type clad steel buildings, however use of good design techniques can help minimise visual intrusion.

6.14 Size and Landtake

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 for source segregated waste will have capacities in the range of 10,000 and 60,000 tpa.

The capacity of ABT facilities within MBT facilities is usually over 50,000 tpa but under 200,000 tpa.

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 than IVC facilities. 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.

Landtake is highly variable, a general rule of thumb is between 0.5 and 1m^2 per tonne of input material will be required. Taller buildings are required for vertical composting units compared to tunnel units.

6. Planning and permitting issues

6.15 Environmental Impact Assessment (EIA)

Some small ABT facilities may not require EIA. However, those which are located within sensitive areas or close to sensitive receptors will require EIA under Schedule II – Part 11 'Other Projects' (b) installations for the disposal of waste – of the EIA Regulations.

6.16 Licensing/permitting

If processing over 50 tonnes a day, a Pollution Prevention & Control (PPC) permit would be required to operate an IVC and AD facility. Most facilities are smaller in size and will require a Waste Management Licence to operate. The Environmental Permitting Programme (EPP) is due to be implemented in April 2008 which will combine waste licensing and permitting systems.

For more information on licensing & permitting see the Environment Agency site.

For more information on licensing & permitting see http://www.environment-agency.gov.uk/subjects/waste/?lang=_e

Box 1 illustrates some of the key planning features of the Wanlip AD facility operated by Biffa Ltd in the planning authority of Leicestershire County Council.

Box 1: Wanlip AD facility

- The 40,000 tpa facility is located on 0.7ha of Severn Trent Water's sewage treatment works
- It is designed to receive the fine organic fraction from the ball mill facility (a mechanical treatment facility receiving residual MSW)
- Application submitted in December 2002 and approved in March 2003 with 14 conditions
- An EIA was not required; site is surrounding by existing industrial land to the north and west with the A46 immediately to the south and east

6.17 Animal By-products Regulations (ABPR)

Any 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 4: 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 hours; max particle size 50mm	Enclosed reactor at 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.

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.

7. Social and perception issues

This section contains a discussion of the social and environmental considerations of ABT facilities.

7.1 Social Considerations

Any new facility is likely to impact on local residents and may result in both positive and negative impacts. Potential impacts on local amenity (odour, noise, dust, landscape) are important considerations when siting any waste management facility. These issues are examined in more detail in the Planning & Permitting chapter of this Brief. Transport impacts associated with the delivery of waste and onward transport of process outputs may lead to impacts on the local road network. The Planning and Permitting chapter of this Brief provides an estimate of potential vehicle movements.

Potential environmental and local amenity impacts, whether real or perceived, can cause a great deal of concern. ABT plants can be large facilities that should be sited carefully, to minimise these impacts (see section 6). ABT facilities may also provide positive social impacts in the form of employment and educational opportunities, as well as a low-cost source of heat (in the case of biogas plants). Table 4 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.

7.2 Public Perception

Changes in waste management arrangements in local areas is creating a higher profile for the service through the media. Many people as a result of greater publicity and targeted education are now embracing the need for waste reduction, recycling and to a lesser extent the need for new waste facilities. The wider perception of waste facilities as a bad neighbour will take longer to overcome.

New waste facilities of whatever type are rarely welcomed by residents close to where the facility is to be located.

Public opinion on waste management issues is wide ranging, and can often be at extreme ends of the scale. Typically, the most positively viewed waste management options for MSW are recycling and composting. However, this is not necessarily reflected in local attitudes towards the infrastructure commonly required to process waste to compost, or sort mixed recyclables, or indeed to have an extra wheeled bin or box. It should be recognised that there is always likely to be some resistance to any waste management facility within a locality, despite the necessity to have the capacity to deal with societies waste.

Overall, experience in developing waste management strategies has highlighted the importance of proactive communication with the public over waste management options. The use of realistic and appropriate models, virtual 'walk – throughs' / artists impressions should be used to accurately inform the public. Good practice in terms of public consultation and engagement is an important aspect in gaining acceptance for planning and developing waste management infrastructure. Defra are funding the development of small to medium scale demonstration plant in England for local authorities to visit and for Defra to publish data on performance.

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.

Defra is funding the development of small to medium scale demonstration plant in England for local authorities to visit and for Defra to publish data on performance. For more information contact Wastetech@enviros.com.

8. Cost

In this section, the cost of ABT facilities with anaerobic and aerobic processes is discussed.

The costs below in Table 5 illustrate the estimated gate fee for different biological treatment technologies recently published by WRAP[16]. The gate fee for in-vessel composting is suggested for a typical capacity of between 10-20,000 tpa. A recently published study by Defra however suggests that the practical, optimum capacity for IVC is 50,000 tpa, using a transport and process cost model[17]. ABT facilities require considerably more capital expenditure compared with windrow composting. Costs are associated with buildings, concrete slabs, monitoring equipment and other costs associated with ensuring facilities are ABPR compliant.

Table 5: Typical gate fees for biological treatment processes

Biological Process	Gate Fee (£/t)
Windrow composting	£19
In-vessel Composting	£35-40
Anaerobic Digestion	£55-65

The variation in magnitude and ranges of costs are due to the wide variety of systems available on the market, plant capacities, and the level of mechanical automation used. Capital expenditure for IVC is estimated to be between £30 and £60 per tonne per annum.

The cost of an AD system will depend on the size of the facility and will vary between technology providers. As an indication of possible costs, a large 1 MWe capacity facility will cost:

- £3 to 4 Million capital expenditure
- Up to £100,000 per annum running costs

[16] Managing biowastes from households in the UK: Applying life-cycle thinking in the framework of cost-benefit analysis. Eunomia Research and Consulting for Waste & Resources Action Programme, May 2007

[17] Economies of Scale - Waste Management Optimisation Study by AEA Technology for Defra, April 2007

9. Contribution to national targets

9.1 Best Value Performance Indicators (BVPI)

BVPI 82b: Composting and Anaerobic Digestion

Compost generated through the processing of source segregated organic material by in-vessel composting will contribute to BVPI 82b, the indicator for the amount of composting a local authority has achieved. The definition of BVPI 82b now also includes waste which has been treated through a process of anaerobic digestion.

Where MBT processes are configured to produce an organic rich stream known as a compost-like output (CLO) from mixed residual MSW to be utilised as a low grade soil conditioner for example, this material may (but is 'unlikely to' see below) qualify as composting under BVPI 82b. The CLO could be utilised in applications such as brownfield restoration, landfill restoration or some bulk fill uses (provided that the appropriate engineering and quality standards are met).

These materials will only qualify as 'composted' under the Best Value Performance Indicator (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 definition could be achieved then the product would qualify as BVPI 82b.

The Government has recently increased national recycling and composting targets for household waste through the *Waste Strategy for England 2007*. Targets are at least 40% by 2010, 45% by 2015 and 50% by 2020. For more information on the contribution of ABT to Best Value Performance Indicators and recycling see the local authority performance pages on the Defra website

http://www.defra.gov.uk/environment/waste/localauth/perform-manage/index.htm and http://www.wastedataflow.org/Documents/BVPI%20FAQs.pdf

9.2 Landfill Allowance Trading Scheme (LATS)

The European Landfill Directive and the UK's enabling act, the Waste & Emissions Trading Act 2003, require the diversion of biodegradable municipal waste (BMW) from landfill. LATS (known as the Landfill Allowances Scheme, LAS, in Wales) began in 2005, and places increasing restrictions on the amount of biodegradable municipal waste (BMW) going to landfill, in line with the EU Landfill Directive targets. Local authority allowances for the amount of BMW they can send to landfill have been set in relation to their total MSW arisings in 2001/2.

The ability for ABT processes to divert BMW depends on the input material, the type & quality of outputs produced and the markets or outlets found for the outputs. The treatment of source segregated biodegradable waste will produce compost or digestate and liquor, all of which can potentially find a market and result in the full diversion of BMW from landfill.

9. Contribution to national targets

The biological processing stage of an MBT facility will be able to contribute to these targets in two ways: 1) by turning BMW into a compost-like output for use on land; or 2) by reducing the mass and biodegradability of BMW prior to landfill.

A compost-like output has more limited applications to land than compost produced from source segregated waste because of its lower quality. If a WML exemption can be obtained for the application of the CLO to land then BMW is diverted from landfill.

However, MBT plant can also be used to bio-stabilise waste prior to landfilling. In this case biological treatment is used to reduce the waste's potential to degrade and produce methane once landfilled. The Environment Agency (EA) has developed a methodology to determine the 'stability' or 'biodegradability' of any outputs from an MBT plant which are sent to landfill. This methodology can be used to determine the actual amount of biodegradable material being landfilled. This information could help an authority achieve allowance allocations under the Landfill Allowance Trading Scheme (LATS). The testing is not a statutory requirement currently. Detailed guidance on how the diversion of biodegradable waste is measured in MBT processes can be found on the Environment Agency website:

http://www.environment-agency.gov.uk/commondata/acrobat/mbt_1154981.pdf

Up to date information can be obtained from Defra's LATS information webpage:

http://www.defra.gov.uk/environment/waste/localauth/lats/index.htm

9.3 Renewable Obligation Certificates (ROCs)

The Renewables Obligation (RO) was introduced in 2002 to promote the development of electricity generated from renewable sources of energy. The Obligation requires licensed electricity suppliers to source a specific and annually increasing percentage of the electricity they supply from renewable sources, demonstrated by Renewables Obligation Certificates (ROCs). The target currently rises to 15.4% by 2015/16. In essence, the RO provides a significant boost to the market price of renewable electricity generated in eligible technologies.

Electricity generated from the biomass (renewable) fraction of waste by anaerobic digestion is eligible for support under the RO. In the case of ABT, this applies to the electricity generated from the biogas. This can provide an important additional revenue stream for a proposed plant, as long as it meets the qualifying requirements. As the value of a ROC is not fixed, the long term value would need to be assessed in detail to determine its overall financial value to the project.

The Department for Industry (DTI) is considering providing greater support to technologies producing renewable energy and assessing methods for removing barriers to renewable energy generation.

Up-to-date information regarding RDF and ROCs can be obtained from the DTI website

www.dti.gov.uk/energy/sources/renewables/index.html.

10. Further reading and sources of information

WRATE (Waste and Resources Assessment Tool for the Environment)
http://www.environment-agency.gov.uk/wtd/1396237/?version=1&lang=_e

The Waste Technology Data Centre www.environment-agency.gov.uk/wtd

New Technologies Demonstrator Programme Wastetech@enviros.com

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

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*.

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

Greenpeace Environmental Trust (2003) *Cool Waste Management: A State-of-the-Art Alternative to Incineration for Residual Municipal Waste: MBT*

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

Office of the Deputy Prime Minister's guidance:
http://www.odpm.gov.uk/stellent/groups/odpm_localgov/documents/page/odpm_locgov_609123-10.hcsp

GLA / S. McLanaghan (2003) *City Solutions: New and Emerging Technologies for Sustainable Waste Management* ISBN: 1-85261-491-2

10. Further reading and sources of information

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

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

Enviros & Deloitte (2004) *Report for the Mayor of London. Capital Solutions: Guidance for funding and procuring new and emerging waste recovery technology*. ISBN 1 85261 644 X.

Strategy Unit (2002) *Waste Not, Want Not*. The Stationary Office.

European Environment Agency (EAA) (2002) *Biodegradable Municipal Waste Management in Europe*. EEA Part 3 Technology & Market Issues. Available from the European Environment Agency website at: 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: Local Authority funding http://www.defra.gov.uk/environment/waste/localauth/funding/pfi/index.htm

The Local Government PFI project support guide www.local.odpm.gov.uk/pfi/grantcond.pdf

For Works Contracts: the Institution of Civil Engineers 'New Engineering Contract' (available at www.ice.org.uk).

For large scale Waste Services Contracts through PFI and guidance on waste sector projects see the 4ps, local government's project delivery organisation
http://www.4ps.gov.uk/PageContent.aspx?id=90&tp=Y

Planning for Waste Management Facilities – A Research Study. ODPM, 2004.
http://www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_030747.pdf

http://europa.eu.int/comm/environment/waste/compost/econanalysis_finalreport.pdf.

11. Glossary

Aerobic	In the presence of oxygen.
Anaerobic	In the absence of oxygen.
Anaerobic Digestion	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.
Animal By-Products Regulation	Legislation governing the processing of wastes containing, or having come in contact with, materials derived from animal sources.
Auger	Helical shaft, or shaft fitted with a screw-thread, designed to bore into and/or move material along its length.
Baffle	Rigid plate used to direct the flow of material.
Biodegradable	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, wood and a proportion of other wastes, such as textiles.
Biogas	Gas resulting from the fermentation of waste in the absence of air (methane/carbon dioxide).
Biodegradable Municipal Waste (BMW)	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.
Composting	Biological decomposition of organic materials by micro-organisms under controlled, aerobic, conditions to a relatively stable humus-like material called compost.
Digestate	Solid and / or liquid product resulting from Anaerobic Digestion.
EPA 1990	Environmental Protection Act.
Feedstock	Raw material required for a process.
Greenhouse Gas	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_2), methane (CH_4), nitrous oxide (N_2O), ozone, water vapour and some of the chlorofluorocarbons.
Green Waste	Vegetation and plant matter from household gardens, local authority parks and gardens and commercial landscaped gardens.
In-vessel Composting	The aerobic decomposition of shredded and mixed organic waste within and 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.

11. Glossary

Mechanical Biological Treatment (MBT)	A generic term for mechanical sorting / separation technologies used in conjunction with biological treatment processes, such as composting.
Municipal Solid Waste (MSW)	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.
Recyclate/Recyclable Materials	Post-use materials that can be recycled for the original purpose, or for different purposes.
Recycling	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.
Refuse Derived Fuel (RDF)	A fuel produced from combustible waste that can be stored and transported, or used directly on site to produce heat and/or power.
Renewables Obligation	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.
Source-segregated/ Source-separated	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.
Statutory Best Value Performance Indicators (BVPI)	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.
Tine	Point, or spike protruding from a central shaft to agitate and break-up material during turning.