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Advanced Biological Treatment of Municipal Solid Waste

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Preamble

This Waste Management Technology Brief, originally produced in 2007, is one of a series of documents prepared under the New Technologies work stream of the Defra Waste Implementation Programme. This Brief has been revised to accompany the 2013 Energy from Waste Guide while remaining a standalone document. The Briefs address the main technology types that have a role in diverting Municipal Solid Waste (MSW) from landfill.

This Brief has been produced to provide an overview of Incineration Technology, which recovers energy from the combustion of MSW. Other titles in this revised series include: Advanced Biological Treatment, Mechanical Biological Treatment, Mechanical Heat Treatment, Advanced Thermal Treatment.

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 but also members of the public who require more detailed information on the technologies mentioned in the 2013 Energy from Waste Guide. It should be noted that these documents are intended as guides to each generic technology area.

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).

1. Introduction

Residual Municipal Solid Waste (MSW) is waste that is household or household like. It comprises household waste collected by local authorities, some commercial and industrial wastes e.g. from offices, schools, shops etc that may be collected by the local authority or a commercial company. Legislation limits (by implication[1]) the amount of mixed MSW that can be sent to landfill.

One of the guiding principles, now enshrined in law, 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).

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 (IVC) and anaerobic digestion (AD).

This guide is designed to be read in conjunction with the other Waste Management Technology Briefs in this series.

Other relevant sources of information are identified throughout the document.

[1] Targets pertain to the biodegradable fraction in MSW.

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, green garden waste and food waste. ABT has also been used for sewage sludge treatment and in agriculture. Advanced Biological Treatment processes can also be used to treat the biodegradable fraction mechanically separated from mixed, residual MSW at a Mechanical Biological Treatment (MBT) facility, with increasing numbers of these types of application in the UK.

This guide is designed to be read in conjunction with the other Waste Management Technology Briefs in this series, and further 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 long term.

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[2];
- 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:

[2] Compost that has been produced from source segregated waste is currently only allowed to be applied to agricultural land.

- Reducing the dry mass of BMW prior to landfill;
- Reducing the biodegradability of BMW prior to landfill;
- Stabilisation into a compost-like output (CLO)[3] for potential use on land (although markets are 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.

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.

Composting (Aerobic) Processes

During composting process, biodegradable material is decomposed into carbon dioxide (CO_2), water (H_20), and heat through microbial respiration in the presence of

[3] Compost-like Output (CLO) is also sometimes referred to as 'stabilised bio-waste' 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.

oxygen (Figure 1) leaving a stabilised residual solid material, compost[4]. 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.

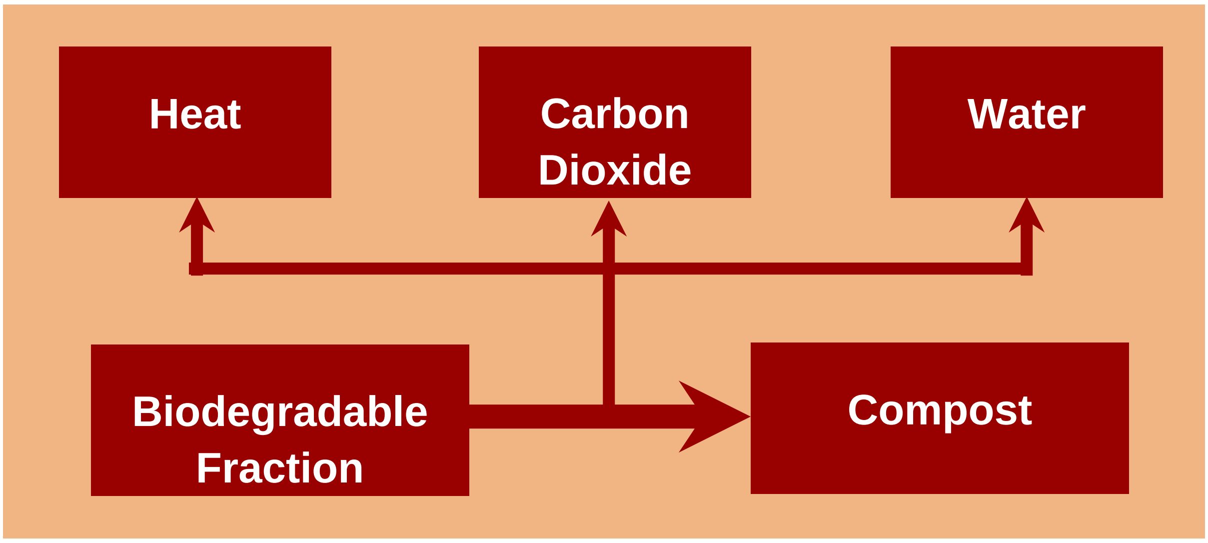

Figure 1: Composting Process

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 composting processes require a net input of energy to supply the oxygen necessary. 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 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.

Thermophilic Aerobic Digestion (TAD) technology is a type of in-vessel composting used in other industries (e.g. waste water treatment, agriculture) which has the

[4] Stabilised is the degree of processing and biodegradation at which:

a) The rate of biological activity under favourable aerobic biodegradation has slowed;
b) The microbial respiration will not revive significantly until environmental conditions are altered.

potential to be utilised for food waste or other semi-solid slurries / liquids. It is a composting process that takes place under aerobic conditions within a digestion vessel. The vessel is heated to ensure that thermophilic (55-65^{o}C) temperatures are maintained, and akin to other In-Vessel Composting technologies is a net user of electricity. The residence time is relatively short under Thermophilic Aerobic Digestion conditions (2 – 5 days), and the output may be de-watered and dried for use as a soil conditioner / compost. Whilst the technology has a track record in the other sectors it has limited application for municipal waste treatment to date[5].

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 either a ‘wet’ process used for materials with moisture contents more than 85% or a ‘dry’ process used for materials with moisture contents less than 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, or cleaned for use as a fuel or injection into the national grid[6]. 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 de-watered into its solid and liquid fractions. Sometimes these two fractions may both be referred to as ‘digestate’, but for clarity they will be referred to as digestate (solid) and liquor (liquid) in this publication.

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[5] For more information: http://www.wrap.org.uk/content/thermophillic-aerobic-digestion.

[6] For example, Adnams Bio Energy in Suffolk digests 12,500tpa of mixed brewery and food waste with excess gas production exported to the grid. The pilot project was funded by DECC, ERDF and EEDA at a development cost of £2.75m.

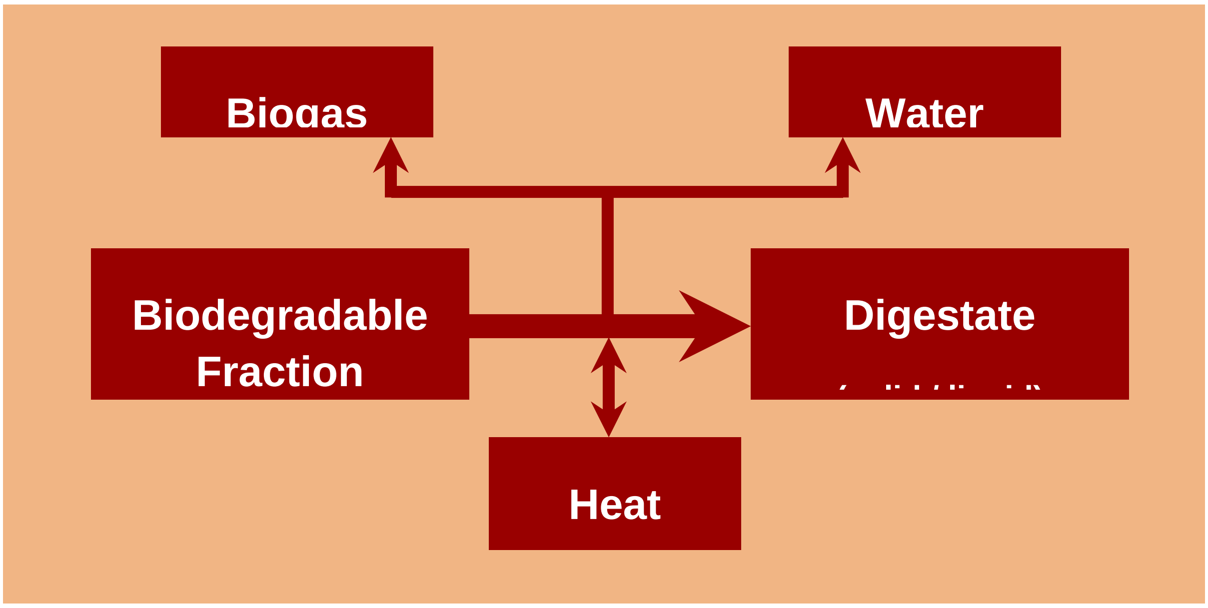

Figure 2: Anaerobic Digestion

A useful reference source on Anaerobic Digestion is the AD Portal maintained by the National Non-Food Crops Centre (NNFCC), http://www.biogas-info.co.uk.

2.4 Composting Technologies

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 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).

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 / Batch	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 and mechanical agitation
	Continuous	Mechanical agitation
		Forced aeration and mechanical agitation

Table 1: Technology Options

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.

Waithlands In-Vessel Composting facility, image courtesy of Viridor

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 of the vessel (or compartment) using augers or scraping arms.

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

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.

Housed 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.

Bio-drying Variations

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 offsets to some extent the energy gained from burning a waste with a higher calorific value.

2.5 Anaerobic Digestion (Biogas) Technologies

Anaerobic Digestion (AD), also known as ‘biogas’, technologies are designed and engineered to control and optimise the biological digestion of biodegradable materials to produce a methane rich 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 three to six 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.

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

Table 2: AD (Biogas) Technology Options

‘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 bio-solids. 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 remove packaging[7] contaminants in source segregated waste streams, or 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. Typical waste feedstocks for a ‘dry’ process include garden waste and energy crops with greater ‘structure’. ‘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 (often 20-45%) and greater biological heat production, although can operate at both temperature ranges. ‘Wet’ AD processes can also 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.

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).

[7] For further information on de-packaging equipment see http://www.wrap.org.uk/content/food-waste-depackaging-equipment

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 3.6), 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. Increasingly there is interest in the option of cleaning the biogas and injection into the gas grid or for use as vehicle fuel.

Biogas cleaning equipment

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 de-watered 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.

2.6 Energy Balance Benefits and Feedstock Issues

IVC and AD treat similar wastes that may be complimentary and not necessarily competing technologies due to the differing outputs produced from each technology process. From an energy consumption and greenhouse gas emissions reduction point of view, there is merit in having an AD stage first followed 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, during aeration of 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 material streams are inherently better suited to either processing through composting or 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 ABT 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. The management of the outputs from ABT processes treating residual MSW are discussed in more detail in the Mechanical Biological Treatment 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, legislative and market conditions.

Compost from Waterswallows In-Vessel Composting facility. Image courtesy of SITA.

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 may be suitable for use, providing it meets the necessary standards and end-use requirements, in a number of sectors[8]:

- Land restoration and soft landscaping operations;
- Horticulture (including domestic use); or
- Agriculture and soil-grown 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[9]. 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.

Parameter	BSI PAS 100 limit
Cadmium (Cd)	1.5 ppm (of dry matter)
Chromium (Cr)	100 ppm (of dry matter)
Copper (Cu)	200 ppm (of dry matter)
Mercury (Hg)	1 ppm (of dry matter)
Nickel (Ni)	50 ppm (of dry matter)
Lead (Pb)	200 ppm (of dry matter)
Zinc (Zn)	400 ppm (of dry matter)
Non-stone contaminants >2mm	0.25%; of which 0.12% maximum can be plastic
Gravel & stones	>4mm ('other than' mulch grade): <8% mass (of dry-air sample) >4mm (mulch grade): <10% (of dry-air sample)
Pathogens	E.coli: 1000 CFU/g (of fresh mass) Salmonella: absent in test of 25g fresh mass
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.	

[8] The 'designated market sectors' set out in the Compost Quality Protocol (See next page).

[9] 'PAS 100:2011 Specification for composted materials', BSi, January 2011. Further information and specification request form available at http://www.wrap.org.uk/content/bsi-pas-100-compost-specification.

Table 3: BSi PAS 100:2011 Criteria*

The Environment Agency and WRAP have produced a Quality Protocol[10] alongside key industry bodies. The protocol sets out to:

- Clarify the point at which waste management controls are no longer required;
- Provide users with confidence that the compost they purchase conforms with an approved standard; and
- Protect the environment and human health by describing acceptable good practice for the use of quality compost on land used for agriculture or soil-grown horticulture.

The quality protocol only allows source segregated wastes, such as garden and food wastes, to be utilised[11]. 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). The UK was in advance of the rest of the EU in developing this protocol, and recently, similar developments at an EU level mean that the current form of the protocol may be superseded by an EU Regulation, pending agreement and ratification.

The application of compost like outputs (CLO) from mixed municipal waste sources is explored in further detail in the Mechanical Biological Treatment Waste Technology Brief. Trials on the use of CLO on land have also been permitted by the Environment Agency[12].

3.3 Use of Digestate on Land

Digestate and liquor are both sources of nutrients, particularly nitrogen, which offer great potential for energy and emissions savings compared with artificially manufactured fertiliser. The Environment Agency, WRAP and partner organisations have produced a quality standard (BSi PAS 110[13]) and Protocol

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[10] 'Quality Protocol: Compost: The Quality Protocol for the production and use of quality compost from source-segregated biodegradable waste', Environment Agency and WRAP, 2010.

[11] A list of applicable input wastes are listed in appendix B of the protocol.

[12] http://publications.environment-agency.gov.uk/PDF/GEHO0512BWLS-E-E.pdf

[13] 'PAS 110:2010 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials', BSi, February 2010. Further information and specification request form available at http://www.wrap.org.uk/content/bsi-pas-110-specification-digestate.

[14] for digestate and liquor from AD that will function in a similar way to the Composting Protocol to ease the regulatory barriers to using the outputs from AD. This qualifies as end of waste criteria in England at present. However, as noted in section 3.2 new end of waste criteria is being developed at an EU level, which will supersede the domestic specifications, and is likely to take the form of an EU Regulation, anticipated to be published during summer 2012.

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).

3.4 Environmental Permitting

The latest version of the Environmental Permitting Regulations 2012[15] requires that, unless a quality protocol applies, an environmental permitting exemption is obtained by land owners/managers before any compost, digestate or liquor derived from source-segregated waste materials can be applied to agricultural land.

The use or disposal of a compost like output (CLO) derived from a mixed waste source (for example from a Mechanical Biological Treatment process) is subject to the waste permitting controls under the Environmental Permitting Regulations. Its use on land must also meet the requirements of the Animal By-Products Regulations (ABPR).

The quality of CLO produced will vary with different MBT technologies, the quality of raw waste inputs, and the method and intensity of waste preparation and separation prior to biological treatment, as well as the methods used to screen and / or wash the outputs. Subject to its quality, it may be possible to use it in the restoration, reclamation or improvement of previously developed land. This will need to be authorised by the Environment Agency (EA) under a mobile plant permit and deployment form. The deployment form is submitted by the operator and contains the site specific information to demonstrate that the CLO will be beneficial, a risk assessment, and the control measures proposed by the operator.

The use of CLO produced from mixed MSW on agricultural land is currently not permitted by the EA. If an outlet cannot be found for the CLO then it may have to be disposed to landfill. This will incur a disposal cost and any remaining measured

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[14] 'Quality Protocol: Anaerobic Digestate: End of waste criteria for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable waste', Environment Agency and WRAP, 2010.

[15] The Environmental Permitting (England and Wales) (Amendment) Regulations 2012 (SI 2012/630). The regulations replace the 2010 and previously 2007 versions which had combined Waste Management Licenses (WML) and Pollution Prevention and Control (PPC) Regulations.

biodegradable content will affect local authority landfill diversion targets. Further guidance is provided in the Planning and Permitting chapter of this document.

3.5 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[16]. These sites must therefore meet all treatment and hygiene standards required by source-segregated waste composting/biogas plants (see Chapter 6.2).

Mixed MSW will contain household kitchen ('catering') waste including meat, and as such will, at least, fall under UK national ABPR 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[17] standards.

3.6 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 and engines. 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 up 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[18], Renewable Heat Incentive[19] and Feed-in-Tariff[20] schemes (see Section 9.4).

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[16] The Animal By-Products (Enforcement) and Transmissible Spongiform Encephalopathies (England) (Amendment) Regulations 2011 (SI 2011/2681).

[17] Regulation EC 1774/2002 on laying down health rules concerning animal by-products not intended for human consumption.

[18] For more information on the Renewables Obligation (RO) see the DECC website, http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/renew_obs/renew_obs.aspx.

[19] For more information on the Renewable Heat Incentive (RHI) see the DECC website, http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx.

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 (potentially in the range of 90%) 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 are available users.

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; pressurisation to boost gas pressure; and removal of carbon dioxide to increase the calorific value of the biogas. The cost of the equipment required to upgrade biogas can be significant, however the application of Renewable Heat Incentives is a measure to encourage investment in this type of energy recovery technology. Case studies in section 4 illustrate examples in practice in the UK.

3.7 Refuse Derived Fuel (RDF)

RDF is not usually an output from ABT accepting source segregated waste only. For MBT technologies it is more common that an RDF is produced that can be used in thermal treatment facilities (see the ATT and Incineration Technology Briefs). In order to use RDF from an MBT technology a drying and stabilisation process is required to produce a suitable product. For further information on RDF outlets please refer to the MBT Technology Brief.

[20] For more information in the Feed-in-Tariffs scheme (FITs) see the DECC website, http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/feedin_tariff/feedin_tariff.aspx.

4. Track Record

ABT technologies such as In-Vessel Composting (IVC) and Anaerobic Digestion have been proven for source segregated materials overseas and in the UK. The examples illustrated here are for UK ABT facilities processing source segregated wastes; for examples of facilities using ABT within MBT processing mixed residual MSW, please see the separate MBT Brief within this series.

4.1 Composting (Aerobic) 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. There were 41 permitted IVC facilities, with a maximum capacity of 1,778,000tpa, as of March 2010[21].

As the anaerobic digestion technologies proliferate, it is likely that there will be competition for municipal organics containing animal by-products, and the numbers of IVC plant may fall in the light of the alternative capacity in the market.

Case study: In-Vessel Composting Process – Viridor

Waithlands IVC processes 25,000 tonnes / year of kerbside collected food and green garden waste (Biowaste) from householders to produce 16,000 tonnes / year of BSi PAS100 and Compost Quality Protocol accredited high quality compost. This material is matured and screened to 0 – 10mm and sold for inclusion in bags of multi-purpose compost which is then sold in garden centres, a genuine closed loop recycling solution.

4.2 Anaerobic Digestion (Biogas) Technology

This technology was originally proven on sewage sludge across the UK water industry, with some experience in the agricultural sector. Defra funded a demonstrator plant in Ludlow as part of the new technologies programme to use AD

[21] 'England's Waste Infrastructure: Report on facilities covered by environmental permitting: 2010', Environment Agency, October 2011. It should be noted that these capacity figures are upper limits of permits rather than actual throughput.

for treatment of food waste (with some garden waste), and subsequently the Government has sought to increase anaerobic digestion capacity in the light of studies highlighting the benefits[22] of using the technology for municipal organics such as food waste.

The support for AD through the implementation of the Government AD Strategy and Action Plan[23] and renewable energy incentives has driven a substantial increase in AD of source segregated municipal food waste. This trend is likely to continue over the short term (Figure 3).

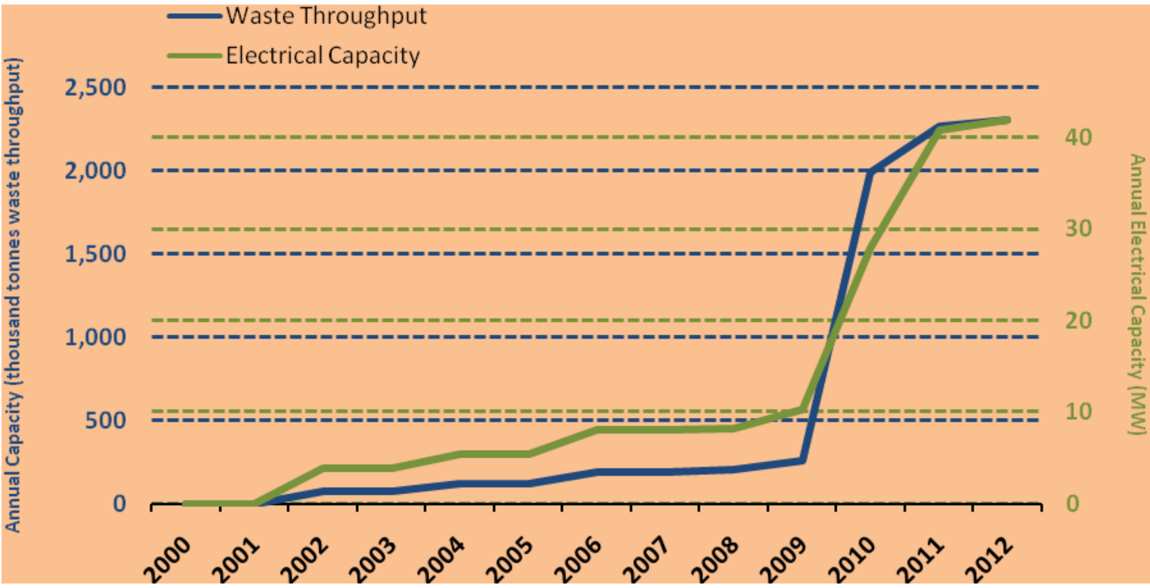

Figure 3: Waste-fed AD Plant Capacity and Power Output. Data Sourced from NNFCC AD Portal

In England there were 30 permitted AD sites as of March 2010[24], with a combined capacity of over 6,000,000tpa (the majority of these plants and capacity handle sewage sludge, however 552,000tpa of the capacity handles food and garden wastes). There are also a large number of AD facilities going through the planning process or under development.

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[22] AD has performed well in Life Cycle Assessments and Cost Benefit Analysis of food waste management options

[23] This was developed and supported by a range of stakeholder organisations including industry and the regulators, and is available at http://www.defra.gov.uk/publications/files/anaerobic-digestion-strat-action-plan.pdf.

[24] 'England's Waste Infrastructure: Report on facilities covered by environmental permitting: 2010', Environment Agency, October 2011. It should be noted that these capacity figures are upper limits of permits rather than actual throughput.

Case Study - AeroThermal Group Limited - Advanced Anaerobic Digestion (AAD) Technology

AeroThermal's AAD technology consists of a front-end autoclave technology with back-end anaerobic digestion designed to significantly increase the generation of biogas from the organic fraction of waste materials. The autoclave process provides for the pre-processing of organic wastes, and the separation of recyclable materials if processing mixed residual wastes. Post-autoclave, the organic fraction of the waste has been broken down and reverted back to its original cellulose form. The lignin compound of the organic fraction then is attacked and the material cell structure is changed, so the now "hydrolysed" material is well suited to complement anaerobic digestion. A traditional anaerobic digestion arrangement is then utilised to process the hydrolysed material and generate biogas.

The autoclave itself utilises "direct steam injection" (with a steam contact time of 45 minutes) and sterilises everything within the pressure vessel, which enables processing of totally unsorted municipal wastes.

AeroThermal secured its first planning permission in 2011 for a 75,000 tonne per annum facility in Lee Moor, near Plymouth in Devon known as "AAD (South West) Ltd". The plant utilises redundant kaolin settlement tanks for the AD process and existing buildings to house a two-line autoclave arrangement with electricity fed into the national grid by utilising an existing grid connection. The resulting digestate produced from the Lee Moor facility is intended to be applied for the restoration of the china clay quarry operated by Imerys Minerals Ltd at Lee Moor.

4.3 MBT Technology

Several MBT technologies have been proven in the UK and mainland Europe (see MBT Technology Brief in this series for further information) using an assortment of different mechanical and biological processes, including anaerobic and aerobic processes.

In England MBT capacity is increasing rapidly, with large scale facilities under construction and complete, for examples including Frog Island (East London) and Reliance Street (Manchester) see the MBT Technology Brief.

The least proven aspect of MBT technologies is the final quality and contamination levels of any stabilised organic residues produced, and of recyclate quality from the process.

Bredbury Parkway Anaerobic Digestion Vessels and Gas Holder, image courtesy of Viridor

5. Contractual and Financing Issues

5.1 Grants and Funding

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, which is covered in detail by the Chartered Institute of Public Finance and Accountancy (CIPFA) 2009 Prudential Code for Capital Finance;

Waste Infrastructure (WI) credits and Private Sector Financing: 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. However, there is no intention to issue new WI credits at the date of this publication;

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;

Existing sources of local authority funding: for example from National Non-Domestic Rate payments (distributed by central government)[25], credit borrowing where government credit approvals are received, local tax rising powers (council tax), and income from rents, fees, charges and asset sales (capital receipts). In practice capacity for this will be limited.

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. The Government Green Investment Bank (and its precursor, prior to State Aids approval, UK Green

[25] Except, for example, in 'Core Cities' where authorities may be eligible for infrastructure support through the application of business rates under the 'New Development Deals' and 'Economic Investment Funds' mechanisms of the Governments City Deals programme. See 'Unlocking Growth in Cities: City Deals – Wave 1', HM Government Cabinet Office, July 2012.

Investments) is investing in waste infrastructure. This option may provide financing for appropriate projects moving forward.

WRAP operate an Anaerobic Digestion Loan Fund (ASLF) with a value of £10m to support the development of new AD capacity in England. The fund aims to support 300,000 tonnes of annual capacity by 2015. Funds are available from £50,000 up to £1m for periods up to 5 years. For more information visit the WRAP website, http://www.wrap.org.uk/content/ad-loan-fund.

5.2 Contractual Arrangements

Medium and large scale municipal waste management contracts, since January 2007, are likely to be procured through the EU Competitive Dialogue (CD) programme under the Public Contact Regulations[26]. This is dialogue between an authority and the bidders with the aim of developing a suitable technical or legal position against which all the bidders can submit a formal bid. More information on CD is available from the Local Partnership website at http://www.localpartnerships.org.uk/PageContent.aspx?id=9&tp=Y.

The available contractual arrangement between the Private Sector Provider (PSP) and the waste disposal authority (or partnership) may be one of the following:

[26] The Public Procurement (Miscellaneous Amendments) Regulations 2011 (SI 2011/2053).

<table>
<tr><th>Design</th><th>Build</th><th>Operate</th><th>Finance</th><th>Contractual arrangement description</th></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td><td>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.</td></tr>
<tr><td colspan="2">A</td><td>B</td><td>C</td><td>Design and 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.</td></tr>
<tr><td colspan="3">A</td><td>B</td><td>Design, Build and Operate; Finance: The Design, Build, Operation and Maintenance contracts are combined. The waste authority owns the facility once constructed and makes separate arrangements to raise capital.</td></tr>
<tr><td colspan="4">A</td><td>Design, Build, Finance and Operate (DBFO): This contract is a Design, 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.</td></tr>
<tr><td colspan="4">A</td><td>DBFO with WI: This is a Design, Build, Finance and Operate contract, but it is procured under the Waste Infrastructure (WI) 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 WI grant is only eligible for facilities treating residual waste and is payable once capital expenditure is incurred.</td></tr>
</table>

Table 4: Available Contractual Arrangement Configurations

The majority of large scale waste management contracts currently being procured in England are DBFO 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, for example the Greater Manchester Waste Disposal Authority combining nine of ten unitary authorities in the city region.

Contracts are becoming more 'output' led since contractors increasingly have to build proposals around obligated targets placed on authorities such as for recycling yields.

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.

A fundamentally important issue in consideration of the bankability of any waste treatment project is the acceptable risk profile of the procurement in question (i.e. risk allocation within the contract), and project risk in terms of ability to deliver the infrastructure required (planning, technology, availability, reliability and available secure markets for process outputs). There are a number of steps that may be taken by contracting authorities and waste management solution providers in order to minimise the risk profile and help in the delivery of the project as a whole. The following examples of further reading explore these issues:

- 'Rubbish to Resource: Financing New Waste Infrastructure', Associate Parliamentary Sustainable Resource Group (APSRG), September 2011, available at http://www.policyconnect.org.uk/apsrg/rubbish-resource-financing-new-waste-infrastructure.
- Local Authority funding examples http://www.defra.gov.uk/environment/waste/local-authorities/widp/pfi-projects/.
- Guidance documents on waste management procurement http://www.defra.gov.uk/environment/waste/local-authorities/widp/widp-guidance/.
- For Works Contracts: the NEC3 contracts (available at www.neccontract.com – formerly the Institute of Civil Engineers 'New Engineering Contract').
- Local Partnerships provide guidance to local authorities concerning partnership opportunities and achieving optimum service delivery and efficiencies, http://www.localpartnerships.org.uk/PageContent.aspx?id=198&tp=Y.

6. Planning and Permitting Issues

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[27].

6.1 Planning Application Requirements

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 March 2011. Supplementary guidance is also contained within the Companion Guide to PPS 10[28]. Both of these documents can be accessed via the Department of Communities and Local Government (DCLG) website.

It should be noted that with the publication of the National Planning Policy Framework (NPPF) in March 2011, virtually all pre-existing Planning Policy

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[27] http://www.communities.gov.uk/documents/planningandbuilding/pdf/148385.pdf.

[28] http://www.communities.gov.uk/documents/planningandbuilding/pdf/150805.pdf.

Statements (PPS) and Planning Policy Guidance (PPG) notes have now been replaced. However, as the Framework does not contain specific waste policies since these will be published as part of the National Waste Management Plan for England, PPS10 will remain in place until the new Plan is adopted.

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[29]. 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 (which is likely to be referred to as the 'Local Plan' in the future under the NPPF system). 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.

Key Issues

The primary emissions from these plants are emissions to air, 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;
- Dust / Odour;
- Bio-aerosols;
- Flies, Vermin and Birds;
- Noise;
- Litter;
- Water Resources;
- Nutrient Retention;
- Design Principles / Visual Intrusion;

[29] http://www.communities.gov.uk/documents/planningandbuilding/pdf/1505220.pdf.

- Size and Landtake; and
- Public Concern.

A brief overview of the planning context for each of these issues is provided in the following pages.

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 and states:

> *"Most waste management activities are now suitable for industrial locations, many fall within the general industrial class in the Use Classes Order (as amended).*[30]

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 MRFs and ATTs can be advantageous. The potential for co-location of such

[30] For more information on change of use classes see, http://www.planningportal.gov.uk/permission/commonprojects/changeofuse/.

facilities on resource recovery parks or similar is also 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.

Traffic

ABT facilities may be served by large numbers of Large (Heavy) goods vehicles (LGVs) (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.

Air Emissions / Health Effects

Bio-aerosols are normally found in higher concentrations at facilities where large amounts of organic matter are processed. Although studies have found no increase in cancer or asthma in populations close to composting facilities, there have been public concerns that open composting facilities could in theory affect the health of those living in close proximity.

Available evidence suggests that communities located more than 250m away from composting facilities are unlikely to be exposed to harmful levels of bio-aerosols; however they may experience odours associated with the process as these can travel much further. Bio-aerosol emissions can be mitigated by conducting operations that may give rise to higher quantities of bio-aerosols (such as screening and shredding) within an enclosed building. Further detail is included in the Bio-aerosol section below.

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 enclosed ABT facility.

Dust / 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. Bio-filtration systems, thermal systems or other thermal abatement plant can be used to control 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.

Bio-aerosols

Bio-aerosols may comprise of complex mixtures of micro-organisms transported in the air. They are common in rural environments and may arise from a wide variety of activities including agriculture. Some bio-aerosols can cause health problems, notably *Aspergillus Fumigatus*, but also some other fungal spores and bacteria. It is also apparent that there is a wide variety of susceptibility to bio-aerosols in individuals. One source of bio-aerosols is composting operations and similar waste treatment processes. Raised levels of community exposure to bio-aerosol may arise within 250m downwind of a composting facility and under rare circumstances at distances of up to 0.5 km[31].

The Environment Agency regulate waste management processes and whilst some small scale composting facilities do not require an environmental permit to operate, larger (e.g. municipal waste management) scale facilities will need to operate under an environmental permit issued by the Agency. This will either be a bespoke permit or a standard rules permit. Standard rules permits are available for composting facilities which are to be located more than 250m from dwellings or workplaces as a consequence of risks over bio-aerosols. This aspect is likely to also apply for In-Vessel Composting processes where there is an external maturation / composting element, dry AD processes where the digestate is matured in windrows after the digestion phase and similar aspects of Mechanical Biological Treatment processes[32].

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[31] 'Exposure-response relationships for bio-aerosol emissions from waste treatment processes', WR0606, Defra, 2008.

[32] 'Composting and potential health effects from bio-aerosols: our interim guidance for permit applicants', EA, 2010.

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 passed through fresh inputs waste so temperatures exceed levels at which flies can survive. Similarly, waste storage time in some ABT plant is designed to be less than the breeding cycle of vermin such as rats.

Noise

Noise is an issue that will be controlled under permitting regulations and noise levels at nearby sensitive 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 preparation, turning and aeration of the biomass.

Litter

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

Water Resources

Common to many new waste treatment processes the enclosed nature of the operations significantly reduces the potential for impacts on the water environment. The greatest potential for pollution to surface/ground water is linked to the arrangement for delivery of waste and the collection of processed materials. Pollution of water is unlikely due to ABT facilities being under cover and rainfall is unlikely to come into contact with the process. Even so, any wash down waters or liquid within the waste will need to be managed using a drainage system on site. This is often cited as being reused within the process, but again such process water will need to be managed.

The level of water usage will be specific to the technology and therefore it is not possible to provide detail on the nature of the effluent that might be generated and how it should be managed. However, as part of the permitting requirements for a facility a management plan would be required for effluent.

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.

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.

Design Principles and Visual Intrusion

Current planning guidance in PPS 10 emphasises the importance of good design in new waste facilities, the importance of which is echoed by the National Planning Policy Framework in relation to the design of the built environment as a whole. Good design principles and architect input to the design and physical appearance of large scale buildings and structures such as ABT plant 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.

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;

- Appropriate use of landscaping features (trees, hedges, banks etc.) not for screening but to enhance the setting of the facility;
- 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.

For more information on the role of good design in waste facilities, please see the Defra publication 'Designing Waste Facilities: A Guide to Modern Design in Waste', which can be found at http://archive.defra.gov.uk/environment/waste/localauth/documents/designing-waste-facilities-guide.pdf.

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, and in accordance with local planning and permitting restrictions. Most ABT facilities for source segregated waste will have capacities in the range of 10,000tpa and 60,000tpa. The capacity of ABT facilities handling residual waste (i.e. within MBT facilities) may have larger capacities.

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. Often AD facilities will need to be followed by an aerobic (composting) process to complete stabilisation, and dry the digestate.

Different residence times relate to regulatory requirements (e.g. ABPR[33]), 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 $0.5m^2$ and $1m^2$ per tonne of input material will be required. Taller buildings are required for vertical composting units compared to tunnel units.

Public Concern

Section 7, Social and Perception Issues, relates to public concern. In general public concerns about waste facilities in general relate to amenity issues (odour, dust, noise, traffic, litter etc.). For facilities that form part of a larger development which include thermal treatment of the RDF, health concerns can also be a perceived

[33] For further guidance see section 6.2.

issue. Public concern founded upon valid planning reasons (known as 'material considerations') can be taken into account when considering a planning application.

Environmental Impact Assessment (EIA)

It is likely that an Environmental Impact Assessment (EIA) will be required for an ABT facility as part of the planning process. Whether a development requires a statutory EIA is defined under the EIA Regulations 2011[34]. Care should be taken with the difference in meaning between 'treatment' and 'disposal' when applying these regulations. An ABT facility is a waste treatment facility and is not a waste disposal installation. The existing additional guidance in DETR circular 02/99 is to be withdrawn following the publication of the new EIA Regulations; however no proposals have yet been made as to a replacement.

6.2 Licensing / Permitting

The Environmental Permitting Regulations (EPR) have been amended on several occasions[35] and combined the previously separate Pollution Prevention and Control (PPC) and Waste Management Licensing (WML) Regulations. All commercial scale ABT facilities require a permit. There are Standard Rules designed to deliver a standard Environmental Permit, which can save time and money for the operator, where the rules apply to the treatment facility in question. A range of Standard Rules documents apply to different types of composting and Anaerobic Digestion facility[36]. Where the standard rules do not apply a bespoke permit is required. The Environment Agency will be consulting on Best Available Techniques (BATs) for Anaerobic Digestion technologies in September 2012. A demonstration of BAT forms part of the regulatory regime for most waste treatment processes.

It is the detail and scope of the proposed development, in addition to local environmental circumstances, that will determine the nature and complexity of the permit, and hence the process and, to a certain degree, timescale from initiation to permit determination. Furthermore in some instances multi-operator permits are needed where for example the ABT process may be operated by one contractor and an associated effluent treatment plant may be operated by another, again such aspects can add time and complexity into the permitting process.

The process of obtaining an environmental permit is an initial step in an on-going management process for delivery of the requirements of the Permit and ensuring compliance and use of Best Available Techniques. This may include reporting, improvement plans and other on-going activities. There is also a facility within the

[34] 'The Town and Country Planning (Environmental Impact Assessment) Regulations 2011 (SI 2011/1824).
[35] The latest amendment is the Environmental Permitting (England and Wales) (Amendment) Regulations 2012
[36] For further information, http://www.environment-agency.gov.uk/business/topics/permitting/118404.aspx

regulations for the variation of Permits. In the case of municipal waste treatment facilities, where there is a significant operational life anticipated (15 – 25 years), the option to vary may be an important one to allow incorporation of new technology or methods within the installation. In addition, the Permit may be transferred or surrendered (e.g. at the end of a projects operational life). These aspects should be appropriately considered and will involve management processes and reporting / actions as required by the Environment Agency (for example completion reports, decommissioning plans, etc.).

For more information, please see the permitting pages of the Environment Agency's site at http://www.environment-agency.gov.uk/business/topics/permitting/default.aspx.

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 5 below). The EU ABPR standard requires that all feedstock particles entering the process are 12mm or less in size. ABPR controls as regards temperature and duration for composting and AD processes are included in the table below.

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.

Table 5: National ABPR Minimum Requirements

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.

ABPR & Mechanical Biological Treatment plant

Mechanical Biological Treatment (MBT) plants are mixed waste treatment facilities, which generally seek to stabilise biodegradable material prior to landfill (to reduce its capacity to generate methane), or to reduce its moisture content (hence increasing its calorific value) prior to thermal treatment. Most MBT plants rely upon a composting process (or in some cases, anaerobic digestion) to stabilise residual waste.

The scope of the EU Regulation is such that it applies to catering waste only when:

(i) from means of transport operating internationally;

(ii) (ii) destined for animal consumption; or

(iii) (iii) destined for use in a biogas or composting plant;

(iv) (iv) destined for treatment in a rendering plant.

Thus the controls will apply to MBT plants only if they are producing compost for land application or landfill cover. If they are simply treating the material to remove recyclables prior to landfill or incineration of the residual waste, they will not be controlled. If it becomes apparent that the operation of such plants does pose a risk to animal health, the Animal Health & Veterinary Laboratories Agency (AHVLA) shall consider the need for suitable controls[37]. MBT plants will still be subject to environmental permitting by the Environment Agency or Waste Management licensing, or in some instances a Pollution Prevention and Control permit, by SEPA.

An MBT plant which intends to use the material it produces on land, including as cover for landfill, will be considered to be a composting or biogas plant, and will fall inside the scope of the Regulation. Such operations must be approved by Defra, and must therefore meet all the treatment and hygiene requirements that ordinary composting plants must achieve. As with any other approved composting plant, the MBT plant would need to meet one of the national standards if the plant processes only catering waste or the EU treatment standard if it processes other animal byproducts. It will also require approval from the Environment Agency/SEPA before any of the treated material is applied to land.

[37] Current AHVLA guidance available at http://animalhealth.defra.gov.uk/managing-disease/animalbyproducts/compost-biogas-manure/composting-biogas-of-abp.htm

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 and 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). 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, targeted education and more comprehensive waste services are participating, to a greater extent, in waste reduction and recycling activities. This leads to a greater level of engagement in waste management activity. There is still however a significant challenge with regard to acceptance of waste management facilities.

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.

The Associate Parliamentary Sustainable Resource Group (APSRG) have produced a report concerning waste infrastructure developments including 'incentivising community buy-in'[38], which provides examples of waste infrastructure development in the UK with the techniques utilised to gain public approval.

[38] 'Waste Management Infrastructure: Incentivising Community Buy-In', APSRG, February 2011. More information and download available at http://www.policyconnect.org.uk/apsrg/waste-management-infrastructure-incentivising-community-buy.

8. Cost

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

The costs below in Table 6 illustrate the estimated gate fee for different biological treatment technologies published by WRAP[39]. A published study by Defra suggests that the practical, optimum capacity for IVC is 50,000tpa, using a transport and process cost Model[40]. ABT facilities require considerably more capital expenditure compared with windrow composting. Capital costs are likely to be lower for IVC facilities than equivalent sized AD facilities, however they are net users of electricity and do not benefit from the energy revenue streams available to AD operators. It is in this context that current gate fees (Table 6) are similar. Capital costs are associated with buildings, concrete slabs, monitoring equipment, process vessels, other costs associated with ensuring facilities are ABPR compliant, and (in the case of AD facilities) energy recovery infrastructure.

Biological process	Gate Fee (£/t)
Windrow composting	£25 (£15-£53)
In-Vessel Composting	£44 (£28-£60)
Anaerobic Digestion	£41 (£35-£60)

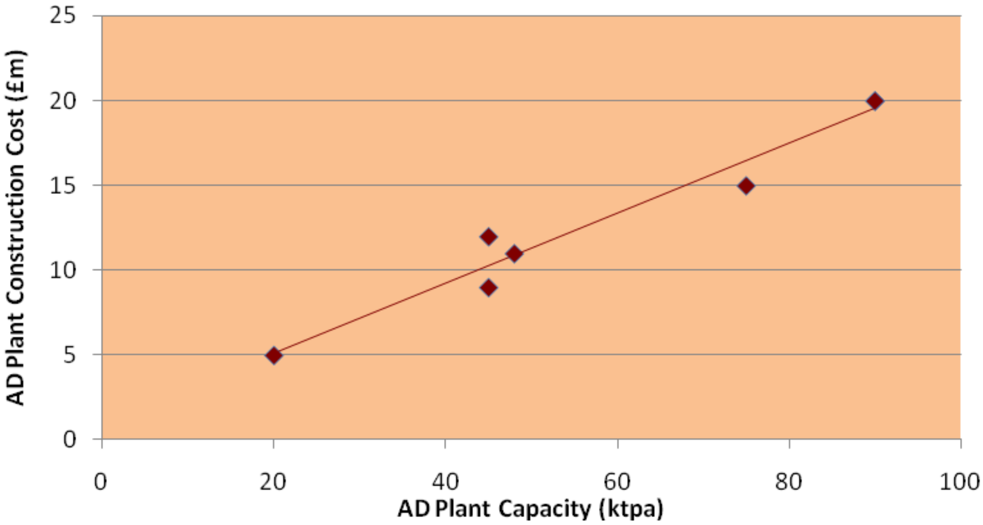
Table 6: Typical Gate Fees (and ranges) for Biological Treatment Facilities

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.

Recent examples of proposed and constructed English AD facility costs are often reported in the press and operator press releases. A selection of facilities are included in Graph 1 showing the relationship between plant throughput capacity and cost.

[39] 'Gate Fees Report, 2012: Comparing the cost of alternative waste treatment options', WRAP, 2012.

[40] 'Economies of Scale - Waste Management Optimisation Study', AEA Technology for Defra, April 2007.



Graph 1: Example Capital Costs of Proposed and Constructed Waste Fed AD Facilities in England

9. Contribution to National Targets

9.1 Recycling

This brief assumes biological treatment of source-segregated organics[41] or a mechanically separated organic rich fraction of MSW. Any materials recycling is envisaged to take place up-stream of this process stage, these aspects are addressed in the MBT brief.

9.2 Composting

Compost and digestate generated through the processing of source-segregated organic material by In-Vessel Composting and Anaerobic Digestion will contribute to national targets for composting and recycling. However, the generation of compost-like outputs / digestate from the mechanically separated organic fraction of municipal wastes (e.g. from an MBT plant) are unlikely to qualify as composting at the present time, and this aspect is likely to become more stringent over time as quality protocols and standards are driven higher.

The revised Waste Framework Directive includes national targets for recycling and composting for household waste set at 50% for 2020. At present the UK as a whole (and England taken separately) is on course to meet these targets.

9.3 Landfill Directive Diversion Performance

The application of ABT processes as a measure to divert organic municipal waste from landfill is an area of intense development in the UK at present. There has been a substantial expansion of separate food waste collections from domestic properties and commercial/industrial food waste producers. Initially, In-Vessel Composting technologies were implemented, and more recently the development of Anaerobic Digestion plant have led to treatment of the segregated organic fraction and application to land as soil conditioners / composts. The diversion of this waste from landfill has resulted in a significant carbon benefit.

There have been several drivers for this method of diverting waste from landfill including the landfill directive targets, the increasing landfill tax rates, recycling

[41] Some contamination, even from source segregated organics is likely to occur and separation of this fraction may yield some recyclate (for example metal cutlery, packaging), separation of such materials would qualify for recycling where markets exist.

ambitions of local authorities and commercial organisations, and (in the case of AD) renewable energy incentives (see section 9.4).

Where the mechanically separated organic fraction of MSW is processed through ABT plant (e.g. as part of an MBT process) this material may be sent to landfill. In these instances the reduction in the biodegradability of that waste will be a factor in determining landfill diversion targets according to the landfill regulations. There is also the potential to dry the compost/digestate for use as an RDF and therefore complete diversion from landfill.

Guidance on monitoring of MBT and other treatment processes for the purposes of landfill diversion targets has been prepared by the Environment Agency, http://publications.environment-agency.gov.uk/PDF/SCHO1009BREB-E-E.pdf.

9.4 Renewables

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 is currently set at 15% by 2020. In essence, the RO provides a significant boost to the market price of renewable electricity generated in eligible technologies. The RO will close to new operators at the end of the 2016/17 financial year. Those already accredited under the RO will continue to receive their full lifetime of support until the scheme closes in 2037.

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, in addition to other renewable energy incentives available.

The Feed-in-Tariffs (FiTs) were introduced by DECC in April 2010 with the intention to encourage deployment of small-scale low-carbon energy generation. Anaerobic Digestion qualifies for FiTs provided energy production is below 5MW per annum. There are three financial benefits associated with FiTs:

1. Generation tariff – Payment per KW energy produced from chosen electricity supplier.
2. Export tariff – If the energy is not used on-site it may be exported to the national grid.
3. Energy bill savings – If the energy generated is used on-site.

Renewable Heat Incentives (RHI) is a £25m support scheme to provide support to the installation of renewable technologies for heat generation, implemented by DECC. The second stage of the scheme is under development at the time of this publication, and further advice will be available on the DECC website.

Further information on the RO, FiTs and RHI can be retrieved from the following sources:

- Renewables Obligation (RO) see the DECC website, http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/renew_obs/renew_obs.aspx.
- Renewable Heat Incentive (RHI) see the DECC website, http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/incentive/incentive.aspx.
- Feed-in-Tariffs scheme (FITs) see the DECC website, http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/feedin_tariff/feedin_tariff.aspx.

10. Further Reading and Sources of Information

Anaerobic Digestion Portal: http://www.biogas-info.co.uk/
Anaerobic Digestion Strategy & Action Plan: http://www.defra.gov.uk/publications/files/anaerobic-digestion-strat-action-plan.pdf
CIWM Anaerobic Digestion guidance: http://www.ciwm.co.uk/CIWM/InformationCentre/AtoZ/APages/AD.aspx.
CIWM Composting guidance: http://www.ciwm.co.uk/CIWM/InformationCentre/AtoZ/CPages/Composting.aspx
DCLG planning guidance: http://www.communities.gov.uk/planningandbuilding/planningenvironment/.
'Designing Waste Facilities: A Guide to Modern Design in Waste', Defra, 2008: http://archive.defra.gov.uk/environment/waste/localauth/documents/designing-waste-facilities-guide.pdf.
'England's Waste Infrastructure: Report on facilities covered by environmental permitting: 2010', Environment Agency, October 2011: http://www.environment-agency.gov.uk/research/library/data/134327.aspx.
General organics recycling information available from: http://www.organics-recycling.org.uk/, http://www.wrap.org.uk/, http://www.nnfcc.co.uk/ and http://www.adbiogas.co.uk/.
'Integrated Pollution Prevention and Control, Reference Document on Best Available Techniques for the Waste Treatments Industries, European Commission' – Directorate General Joint Research Centre, August 2006:

http://ec.europa.eu/environment/ippc/brefs/wt_bref_0806.pdf.
Local Authority funding: http://www.defra.gov.uk/environment/waste/local-authorities/widp/ .
Local Partnerships guidance: http://www.localpartnerships.org.uk/PageContent.aspx?id=198&tp=Y.
'PAS 100:2011 Specification for composted materials', BSi, January 2011: http://www.wrap.org.uk/content/bsi-pas-100-compost-specification.
'PAS 110:2010 Specification for whole digestate, separated liquor and separated fibre derived from the anaerobic digestion of source-segregated biodegradable materials', BSi , February 2010: http://www.wrap.org.uk/content/bsi-pas-110-specification-digestate.
'Quality Protocol: Compost: The Quality Protocol for the production and use of quality compost from source-segregated biodegradable waste', Environment Agency and WRAP, 2010: http://www.environment-agency.gov.uk/static/documents/Business/Compost_Quality_Protocol_GEHO0610BSVC-E-E.pdf.
'Quality Protocol: Anaerobic Digestate: End of waste criteria for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable waste', Environment Agency and WRAP, 2010: http://www.environment-agency.gov.uk/static/documents/Business/AD_Quality_Protocol_GEHO0610BSVD-E-E.pdf.
'Review of Environmental & Health Effects of Waste Management', Enviros Consulting Ltd, University of Birmingham, Open University & Maggie Thurgood, Defra, 2004: http://archive.defra.gov.uk/environment/waste/statistics/documents/health-report.pdf.
Renewables Obligation (RO), Renewable Heat Incentives (RHI) and Feed-in-Tariffs (FiTs) guidance: http://www.decc.gov.uk/en/content/cms/funding/funding_ops/funding_ops.aspx.
'Rubbish to Resource: Financing New Waste Infrastructure', Associate

Parliamentary Sustainable Resource Group (APSRG), September 2011: http://www.policyconnect.org.uk/apsrg/rubbish-resource-financing-new-waste-infrastructure
Trials for the recovery to land for agricultural benefit of compost-like outputs from the treatment of mixed municipal solid wastes, guidance on complying with Environmental Permit requirements: http://publications.environment-agency.gov.uk/PDF/GEHO0512BWLS-E-E.pdf
'Waste Management Infrastructure: Incentivising Community Buy-In', APSRG, February 2011: http://www.policyconnect.org.uk/apsrg/waste-management-infrastructure-incentivising-community-buy.
WRATE (Waste and Resources Assessment Tool for the Environment): http://www.environment-agency.gov.uk/research/commercial/102922.aspx.

11. Glossary

Advanced Thermal Treatment (ATT)	Waste management processes involving medium and high temperatures to recover energy from the waste. Primarily pyrolysis and gasification based processes, excludes incineration.
Advanced Biological Treatment (ABT)	Technologies with a relatively recent commercial application to municipal derived organic waste in the UK, examples being In-Vessel Composting and Anaerobic Digestion.
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 under controlled conditions the waste breaks down, typically into a digestate, liquor and biogas.
Animal By-Products Regulation	Legislation governing the processing of wastes 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	Capable of being degraded by plants and animals.
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 (Aerobic Digestion)	Biological decomposition of organic materials by micro-organisms under controlled, aerobic conditions, to form a relatively stable humus-like material called compost.
Digestate	Solid and/or liquid product resulting from Anaerobic Digestion.
Feedstock	Raw material required for a process.
Feed-in Tariffs (FiTs)	Introduced by the Department of Energy and Climate Change in April 2010 to stimulate deployment of small-scale (less than 5MW) low-carbon energy generation installations. The tariff will guarantee set payments from an electricity supplier of their choice for the electricity they generate and use as well as a guaranteed payment for unused surplus electricity they export back to the grid.
Greenhouse Gas (GHG)	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 / Garden Waste	Waste vegetation and plant matter from household gardens, local authority parks and gardens and commercial landscaped gardens.
In-Vessel Composting (IVC)	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.
Local Authority Collected Municipal	Refers to the previous 'municipal' element of the waste collected by local authorities. That is household waste

Waste (LACMW)	and business waste where collected by the local authority and which is similar in nature and composition as required by the Landfill Directive. This is the definition that will be used for LATS allowances.
Local Authority Collected Waste (LACW)	All waste collected by the local authority. This is a slightly broader concept than LACMW as it would include both this and non-municipal fractions such as construction and demolition waste. LACW is the definition that will be used in statistical publications, which previously referred to municipal waste.
Materials Recycling Facility/ **Material Recovery Facility** **(MRF)**	Dedicated facility for the sorting / separation of recyclable materials.
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)	LACMW plus commercial and industrial waste similar to that generated by households which is collected by commercial operators (i.e. not by or on behalf of a local authority). This is the definition which will be used by the UK for reporting against EU landfill diversion targets. It includes all waste types included under European Waste Catalogue Code 20 and some wastes under Codes 15 and 19.
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 (ROCs), within each electricity supplier must demonstrate compliance with increasing Government targets for renewable energy generation.
Renewable Heat Incentive (RHIs)	A long-term tariff scheme to encourage the replacement of fossil fuel heating with renewable alternatives, led by the Department of Energy and Climate Change. It opened for applications in November 2011 and currently supports renewable heat installations in business, industry and the public sector as well as district heating schemes.
Solid Recovered Fuel	Refuse Derived Fuel meeting a standard specification (CEN 343).
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.
Syngas	‘Synthesis gas’ produced by the thermal decomposition of organic based materials through pyrolysis and gasification processes. The gas is rich in methane, hydrogen and carbon monoxide and may be used as a fuel or directly combusted to generate electricity.
Tine	Poiny, or spike, protruding from a central shaft to agitate and break-up material during turning.