Plymouth City Council Municipal Waste Management Strategy 2007-2030

Supplementary Report 5 of 5

Waste Treatment Technologies

April 2007

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Plymouth

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PLYMOUTH CITY COUNCIL

MUNICIPAL WASTE MANAGEMENT STRATEGY

SUPPLEMENTARY REPORT 5 – WASTE TREATMENT TECHNOLOGIES REPORT

Foreword

Supplementary report 5 – Waste treatment technologies report forms one of a suite of supporting documentation for the Council's Municipal Waste Management Strategy (MWMS) Headline Strategy document. The full suite of documents comprise:

- Headline Strategy – *sets out the adopted option*
- Supplementary Report 1: Baseline Report – *where we are today*
- Supplementary Report 2: Key Drivers – *why we need to change*
- Supplementary Report 3: Stakeholder Workshop Summary Outcomes – *what stakeholders thought were the options we needed to consider*
- Supplementary Report 4: Strategic Options – *Detailed analysis of all the options agreed by stakeholders*
- Supplementary Report 5: Waste Treatment Technologies – *Explanation of the different technologies available*
- Strategic Environmental Assessment (SEA) Environmental Report on the Strategic Options and Municipal Waste Management Strategy – *Considers the social, economic and environmental implications*

The Headline Strategy has been developed following evaluation of a range of treatment technologies. This document should be read in order to gain an understanding of the technologies discussed in the Headline Strategy.

The Council acknowledges the work undertaken by Entec UK Ltd in the development and production of these key reports.

Contents

1. Waste Technology Review

1.1 Introduction

This paper has been produced to accompany the Plymouth Municipal Waste Management Strategy (MWMS) and provide an overview of common waste management technologies. There are a variety of technologies currently used in the UK to manage waste. This report presents and discusses a number of technologies considered for use in Plymouth; however, it is not intended to be a comprehensive list of all waste management technologies currently available. The technologies can treat a variety of waste types ranging from source separated recyclables, organic waste and residual waste. Within this report the term 'residual waste' refers to the waste remaining after reduction, re-use and source-segregation efforts. It is therefore the mixed municipal solid wastes (MSW) that are put out for refuse collection or placed into skips at the civic amenity sites.

The future aim of Plymouth City Council is to promote sustainable resource use from these residual wastes by maximising recovery before disposal to landfill and reducing the amount of waste sent to landfill without any value recovery, as outlined in the waste hierarchy. A number of residual waste treatment technologies are outlined below, along with additional facilities and infrastructure relevant to the Plymouth MWMS.

1.2 Landfill

Historically, landfill has been the preferred waste disposal method in the UK. Disposal of Plymouth's residual waste has consisted almost exclusively of direct delivery to the city's landfill site at Chelson Meadow. This site is to be closed and restored in accordance with its licence conditions. Due to the procurement of a new landfill contract located outside of the city, future unsorted waste will require bulking at a transfer station before onward transport to and disposal of the waste in an engineered landfill site. Modern landfill sites are designed to manage the waste during the lifetime of the site and measures are in place to prevent pollution incidents and problems related to the gases emitted by decomposing waste long after the site has ceased to actively receive waste.

At present, landfill is generally the lowest cost option for waste disposal in the UK. However this disposal route is becoming less attractive due a range of reasons:

- Meeting the requirements of the Landfill Directive;
- Legislative requirements for the diversion or pre-treatment of waste (e.g. targets for reducing biological municipal waste to landfill);
- Reduction in available void space as current rates of landfill usage outstrips the rate at which additional void space receives planning permission;

- Increasing costs due to reduction in void space, more onerous environmental standards for managing and restoring sites, and the landfill tax; and
- Recognition of the need to manage waste in a sustainable manner.

1.3 Mechanical Biological Treatment

The term 'Mechanical Biological Treatment' or 'MBT' is used to describe a range of technologies and processes that are used in the management of Municipal Solid Waste. There is no single MBT technology, but they generally comprise at least two fundamental elements:

- A ***Mechanical*** processing step in which residual waste is treated to remove the most readily captured recyclables such as steel and aluminium from the mixed waste input. The waste often passes through various items of plant and equipment to control particle size and sometimes to separate the waste into different size-fractions. Equipment may include shredders, grinders, bag splitters, trommels, screens, overband magnets, eddy current separators, optical sorting technology, and air separation technology. The various fractions may then be directed to one of a number of further processes.
- A ***Biological*** processing step, in which the input waste or a separated fraction of the waste is treated through some biological activity to change its characteristics. This biological step may be limited to simple 'biodrying' in which the heat produced from initial biological decomposition is used to dry out and stabilise the waste, through to a more extensive aerobic composting step where the aim is to substantially reduce the biodegradability of the waste or anaerobic digestion with the recovery of a biogas fuel.

The configuration of the MBT plant depends on the desired outcome and the characteristics required from the products from the overall process. Two different variations have been examined in this report;

- Production of a solid recovered fuel (SRF), also termed refuse derived fuel (RDF). This is a higher calorific fuel comprised mainly of the lighter fractions of the residual waste such as paper and plastics. It can be combusted in dedicated energy recovery facilities or used by third parties as a fuel substitute, although there are few established market outlets at this time.
- Production of a compost-like output, the production is stabilised and has a reduced biodegradability. This is a low grade soil improver material, could be used for land application, although market outlets are currently uncertain due to contamination risks. In parts of Europe it is often landfilled as landfills may only receive a partially bio-stabilised material.

There is some cross-over between these processes, and both can be configured to further reduce the biodegradability of the reject fraction through a longer composting process or produce and fuel to a specification. The other outputs from MBT plants are typically;

- Recyclables; usually steel and aluminium cans. Some processes are also looking at ways to extract plastics, paper and cardboard.
- Low grade aggregate (glass & stones). Markets for this material are not yet fully developed due to contamination risks.
- Reject fraction. The remaining mixed wastes which are landfilled.
- In addition, moisture is lost through evaporation during the process. This can account for up to 30% of the input tonnage in some cases and is dependant on the technology selected.

Facility Throughput: Typically 60,000 – 180,000 tonnes per annum

Typical Site Size: 1.5 – 5 hectares

Example: *The majority of operational MBT plants are located in Europe and North America. Several UK local authority contracts have been awarded recently that include Mechanical Biological Treatment (MBT). Shanks have recently constructed an MBT plant in East London, and another is near Dumfries using technology from Sistema Ecodeco, an Italian company. This will produce a refuse derived fuel.*

1.4 Anaerobic Digestion

Anaerobic Digestion (commonly referred to as AD or methanisation) is the process by which the biodegradable fraction of municipal waste is broken down in the absence of oxygen to create biogas and a digestate or “compost-like” material. The gas can be used as a fuel for electricity generation or in a combined heat and power generator. For this reason the technology is sometimes classified as an Energy from Waste process along with incineration and advanced thermal treatment. The biogas engines have the added advantage of being able to feed heat and power back into what can be a high-energy consumption process.

In order for MSW to be processed it requires pre-treatment and mechanical processing (such as sorting and shredding) in order to provide a consistent feed to the process. This processing may also extract some materials for recycling.

Water may be added to the organic fraction prior to feeding into the digester in order to improve waste handling. In wet systems a pulping phase will further sort the organic fraction, with plastic film floating to the top and removed. Heavier contaminants such as grit and stones fall to the bottom and are also removed. In semi-wet systems the waste is sorted into more fractions through mechanical sorting.

The digestate resulting from the anaerobic digestion process subsequently requires dewatering and maturation before a stabilised compost-like product is produced. There are uncertainties over the end-uses for the compost-like fractions due to contamination risks. In Europe it is usually landfilled.

Most European plants also produce a solid recovered fuel (SRF) comprising the higher calorific value fraction, that can be for to an energy recovery facility (ERF) cement kiln or power station. With AD as a biological stage in combination with mechanical pre-treatment, the process is another example of Mechanical-Biological-Treatment (MBT).

Facility Throughput: Typically 5,000 to 80,000 tonnes per annum

Typical Site Size: 0.5 to 2.6 hectares

Example*: Anaerobic digestion has been successfully used for many years to treat sewage sludge and has also been used to treat both source-separated waste and residual municipal waste in Europe. Leicester City Council's contractor, Biffa, has constructed the UK's first major anaerobic digester for Municipal Solid Waste at a sewage works, with a capacity of 40,000 tonnes per annum the plant has been designed and configured, for processing the organic fraction of residual waste produced by a separate mechanical pre-treatment process.*

Table 1.1 Anaerobic Digestion - Generic Facility Specifications

Generic Physical and Operational Characteristics		
Plant Size	c.5,000 tpa[1]	c.40,000 tpa[2]
Expected Facility Lifetime	25 years	25 years
Operational Hours	24 hr process, 20 days per month, typically 0700 - 1700 weekdays	20 days per month, typically 0830 - 1730 weekdays and 0800 - 1300 Saturdays
Waste Tonnage Treated	417 tonnes per month	3,333 tonnes per month
Typical Site Area	0.15 hectares	0.6 hectares
Building Footprint	30m x 15m plus 4 circular tanks of 6-10m diameter	40m x 25m plus 2 circular tanks of 15m diameter
Building Height	7m, max. tank height 10m	7m, tanks 6m
Stack Height	No stack	No stack
Vehicle Movements	4 vehicles per day or equivalent	20 vehicles per day or equivalent
Employment	Site Manager plus 2	Site Manager and Foreman plus 3
Waste Storage	Small facilities, segregated waste may be tipped into sealed conditioning tank. No storage of untreated waste outside the building.	Small facilities, segregated waste may be tipped into sealed conditioning tank. Otherwise unsorted waste, segregated waste and residual waste may be stored in open bunkers, possibly outside.

Source: ODPM Report (2004): Planning for Waste Management Facilities: A Research Study

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[1] Data from Greenfinch Ltd

[2] North West Regional Technical Advisory Body, Waste Management Technical Report July 2001

1.5 Autoclaving

Autoclaving (AC) is the process of sterilization via a pressurised, high-temperature steam process, and has more commonly been used for clinical waste. It is also sometimes termed Mechanical Heat Treatment (MHT). The waste is placed in rotating drums where the high pressure steam helps sanitise and reduce residual MSW to a 'fibre' like material. This facility subsequently sorts in to a number of separate fractions. There are currently no operational plants working at a commercial scale in the UK.

The metals, plastics and glass are partially cleaned by the steam and can be extracted for recycling, by various mechanical process although the steam may “melt” some plastics making these more difficult to recycle. Operators are also seeking to extract a glass/grit fraction. It is understood that a number of development projects are seeking to generate useful markets for the fibre. The fibre may be treated by anaerobic digestion in order to stabilise it and generate a biogas. One of the main expected uses of the output is as a solid recovered fuel (SRF), which would require market outlets.

Facility Throughput: Typically 50,000 to 150,000 tonnes per annum

Typical Site Size: 0.3 to 2.0 hectares

Example: There is currently only one large-scale reference plant (Minnesota in the USA), which is designed to produce SRF. There are a number of companies promoting AC systems in the UK, although there are no commercial scale plants at present. A 25,000 tonne pilot plant in South Wales operated for 3 years but has now closed. The SWERF system from Brightstar utilised an autoclave together with a gasification system in Australia, although this has had funding difficulties.

1.6 Energy Recovery Facilities

1.6.1 Introduction

Energy Recovery Facility (ERF) is the generic term adopted in this report for all technologies that convert waste into energy in the form of electricity, heat (for use in district heating), or combined heat and power (CHP). It encompasses both Energy from Waste and Advanced Thermal Treatment as outlined below. It has been used when referring to outlets for Solid Recovered Fuels (SRF) derived from some of the residual treatment systems.

1.6.2 Energy from Waste (Mass Burn Incineration)

In land use planning terms a distinction can be made between ‘mass burn’ plants that are designed to handle large volumes of mixed untreated waste and facilities designed to receive a specific component of the waste stream using different process technologies e.g. combustion of a refuse derived fuel (RDF) output from an MBT technology.

Large scale thermal treatment plants can typically be characterised by large building envelopes which are often located in or near urban areas. Thermal treatment facilities are designed to burn waste under controlled conditions at high temperatures. Heat released from this process is recovered and used to generate electricity and/or to provide heat in the form of steam or hot water, becoming a combined heat and power (CHP) plant.

A number of different types of furnace are possible – the three principal types being grate-based combustion, kilns and fluidised beds. The characteristics of grates and kilns are broadly similar, in that waste is introduced at the top of the grate or kiln and moves down the grate or kiln as it burns. By virtue of the variable nature of the waste stream, EfW plants have tended to be based on moving-grate technology (similar to inclined metal conveyor belts), which can process mixed wastes more effectively. Fluidised beds incinerators add the waste to a heated bed of sand through which air is blown, and differ in a number of respects:

- They require a more sophisticated fuel feed system with a more homogenous feedstock, and may require mechanical pre-treatment. They are therefore well suited to fuels created within an MBT plant;
- They can incorporate in-bed reagents for control of pollutant emissions;
- They can be more sensitive to load variations.

EfW via incineration processes convert about 20-25% of the input mass into a bottom ash and 3% of the input mass into Air Pollution Control residues (APC), with some added treatment agents. The bottom ash is usually suitable for construction uses, with many new facilities having dedicated ash processing plants. If there are no markets for the ash it has to be sent to landfill. The APC stream requires treatment (often solidified) and is sent to a hazardous waste landfill for disposal.

Example*: At the time of writing this paper there are 18 operational EfW incinerators around the country. Many have been commissioned in recent years with a number more currently undergoing procurement and construction. The majority are moving grate systems. A rotating kiln incinerator was opened in 2005 in north Lincolnshire and processes 60,000 tonne per year of municipal waste. A 400,000 tonne per year fluidised bed incinerator is under construction at Allington in Kent.*

Table 1.2 Energy from Waste - Specific Facility Specifications

Location Specific Case Studies		
Location	Chineham near Basingstoke	Billingham, Teeside
Setting	Rural/Urban Fringe	Industrial
Waste Types	Mixed residual waste followed by separation of recyclables	Mixed residual waste followed by separation of recyclables
Waste Volumes	90,000 tonnes per annum	250,000 tonnes per annum
Energy Generation	7 MW	20 MW
Site Area	1.7 hectares	4 hectares
Building Footprint	130m x 45m	110m x 60m x 40m
Stack Height	65m	70m

Source: ODPM Report (2004): Planning for Waste Management Facilities: A Research Study

1.6.3 Advanced Thermal Treatment

Advanced Thermal Treatment (ATT) describes those technologies in which the various processes that occur within conventional combustion are separated spatially, often with the intent of achieving a greater degree of control of the overall combustion process.

Use of advanced thermal treatments requires the pre-treatment of the residual waste into a more homogenous feedstock. This will include the removal of over-size items, removal of some non-combustible materials, and shredding to an appropriate size for the particular technology. These pre-processing operations can provide opportunities to mechanically sort the waste to remove other recyclables such as metals. They may therefore be suitable for treating waste derived fuels from MBT Plants.

Certain pyrolysis and gasification processes have been developed to produce a vitrified (glass-like) residue which is said to have a wider range of possible applications than bottom ash.

Pyrolysis

Pyrolysis involves heating waste in the absence of oxygen at temperatures of 400-800°C. The process also produces liquid oil which is used as a fuel and a char. The heat breaks down complex volatile molecules and resultant gases are then passed into a combustion chamber where they are combined with oxygen and burnt, achieving temperatures of around 1250°C.

At present, due to the additional complexity, cost and technical risks associated with a direct power generation system, many suppliers of advanced thermal technologies tend to couple their technology with a conventional steam cycle to generate electricity and heat, with resulting lower process efficiencies.

Pyrolysis produces a char rich waste material which represents at least 40% by weight of the incoming waste stream and needs to be further combusted in a subsequent process (e.g. in a gasification or incineration system) or landfilled.

Gasification

Gasification converts the bulk of the waste's carbon-containing material into gases by heating it in a reduced oxygen environment. The products from this process form low to medium heating value fuel gases, together with tars, char and ash. These products are ultimately dependent on the type of reactor as well as the waste, but most systems produce a raw gas suitable for direct firing in kilns or boilers.

Fuel production

Some suppliers of advanced thermal technologies promote the concept that they can extract the gasifier product gas and use it as a feedstock for processes producing materials such as hydrogen, methanol or ammonia. Whilst this is commonplace in the petro-chemical industry where the feedstock (crude oil) is homogenous, it is not yet a proven concept on mixed waste as only small pilot trials have taken place.

***Example**: Compact Power have a combined Pyrolysis and Gasification demonstration plant in Avonmouth with a capacity of 6,000 tonnes per annum for clinical waste, and has undertaken limited testing with municipal waste. Under the DEFRA demonstrator programme, Novera/Enerkem have applied to build an 80,000tpa fluidised bed gasification facility in East London, and Energos have applied for a potential facility on the Isle of Wight. It is hoped that with the development of these plants, it will resolve some of the outstanding uncertainties around the application of this emerging technology for waste management applications.*

1.7 Composting

1.7.1 Introduction

Composting plants convert suitable organic biodegradable wastes into a reusable compost by an aerobic degradation process. Three main options of variable capacity and sophistication have been designed; home composting, centralised green waste composting using windrowing technology and centralised composting using in-vessel system with varying levels of process control (including aeration tunnels, silo's and containers). Composting operations should also include, shredding and screening to improve product quality and remove undesirable contaminants.

1.7.2 Home Composting

Plymouth City Council actively encourages the use of home composting and currently offers residents the opportunity to purchase discounted home composting bins. A large proportion of organic waste produced at the household can be composted in a home composting bin. Materials suitable for home composting include;

- Fruit and vegetables (maintaining a variety of fruit and vegetable waste in your mixture is the best way to ensure composting success)
- Citrus fruit peels, cores and pulp
- Grass cuttings (ideally mixed in with more fibrous materials such as shredded paper and scrunched up cardboard)
- Young hedge clippings and fallen leaves (leaves help to speed up the composting process and are a valuable source of nutrients and minerals)
- Personal and household waste including vacuum dust, pet bedding, wood ash, and shredded newspapers are all suitable items for your bin. Compost activators may be added to speed up the breaking down process. They can be purchased in liquid form or can be made at home.

However, there are certain organic materials that should never be placed in a home composting bin. These include;

- Cooked vegetables
- Meat
- Dairy products
- Diseased plants
- Animal excrement or cat litter

Putting these in a home composting bin can encourage unwanted pests and can also create odour. It may also be better to avoid composting perennial weeds (such as dandelions and thistle) or weeds with seed heads.

1.7.3 Windrow Composting

Centralised windrow composting is primarily used for the processing of source segregated green garden waste, such as separate garden waste kerbside collections or segregated garden waste skips at Civic Amenity Recycling Centres (CARC). Windrow composting facilities are not suitable for kitchen or food waste. The collected garden waste is stored in elongated piles which are actively aerated by mechanical turning or by forcing air into the piles using fans. The stabilisation of waste in windrows can take between 8 and 16 weeks (longer in some cases) from reception to final compost production distribution. After composting the stabilised waste is shredded and graded to meet the requirements of its intended markets.

Plymouth City Council offers a garden waste kerbside collection to approximately half of the properties within the city. This source separated waste, along with garden waste collected at the CARC, is processed at a windrow facility located at the Chelson Meadow site in Plymstock.

1.7.4 In-vessel Composting (IVC)

Composting is an aerobic process in which biodegradable waste is decomposed in the presence of oxygen. The principal by-products of the process are carbon dioxide, water and a stabilised residue. In-vessel composting is required if the process is to receive both green and kitchen/catering derived organic waste. The State Veterinary Service (SVS) regulates IVC installations capable of receiving kitchen/catering-derived wastes. The regulations require the separation of pre and post treated materials. The site should therefore allow separation of vehicles delivering waste from those exporting product. In recent years a significant number of IVC facilities have been commissioned and the technology has matured significantly.

The regulations require that the principal processing area be within an enclosed vessel, but not necessarily within a building and locations remote from sensitive receptors may be preferable. Post processing the composted material requires maturation and is usually stored in open piles.

Table 1.3 In-vessel Composting Generic Facility Characteristics

Generic Physical and Operational Characteristics	
Expected Facility Lifetime	10-15 years
Operational Hours	8 hours day, 5-6 days / week
Facility Capacity	25,000 tonnes per annum
Typical Site Area	1 - 2 hectares
Building Footprint	Enclosed building footprint: 25m x 30m
Building Height	4-5m
Active enclosed composting	Windrows in enclosed building, in-vessel unit or tunnels
	Mobile in-vessel containers: 3,000 to 4,000 m²
Vehicle Movements	Approximately 20-40 vehicles per day
Employment	Site Manager, Assistant Manager, plus 3 site operatives
Waste Storage	Storage of inputs from at least one day to up to one week may be required
	Compost storage - 30-40% by volume of input material
	Oversize storage - 10-20% by volume of input material

Source: ODPM Report (2004): Planning for Waste Management Facilities: A Research Study

1.8 Materials Recovery Facilities (MRF)

The main objective of a (MRF) Materials Recovery Facility is to process solid wastes to recover commodity grade materials for sale, or onward processing (paper, aluminium, plastic, biodegradable matter etc.) and to thereby increase the profitability and viability of recycling. At the same time MRF's can divert considerable volumes of waste from landfill into recycling activities. The waste input to a MRF can be mixed, or source separated material from the kerbside collection of household waste, and from industrial and commercial sources. Higher grade products are recovered if the recyclable materials are collected separated from the residual waste.

Plymouth City Council currently operates a MRF at their Chelson Meadow site in Plymstock. The MRF was commissioned in 2000 with an expected lifespan of approximately 5 years with a view of upgrading the facility to a more efficient and up-to-date facility. Approximately 12,000 tonnes of co-mingled dry recyclables are processed at the site each year and the facility has an approximate capacity of 16,000 tonnes per annum.

1.9 Transfer Stations

Transfer stations are used to assist long distance transportation of waste. Waste is generally ‘bulked-up’ into larger capacity vehicles at transfer stations before onward transportation to other facilities or final disposal destinations. The use of transfer stations reduces the number of vehicle movements required by utilising vehicles with larger capacity than those used to initially collect the waste.

1.10 Technologies Summary Table

Table 1.4 presents a summary of the strengths and weaknesses associated with each of the waste management technologies included within the paper.

Table 1.4 Technologies Summary Table -Strengths and Weakness

Waste Technology	Strengths	Weaknesses
Landfill	• Methane can be collected and used for power generation • Can be used as a restoration method for mineral extraction sites • Historically a low cost solution	• Putrescible waste produces landfill gas and leachate • Potential dust, odour and vermin problems if site is not well managed • Stabilisation of landfill site can take up to fifty years • Can have detrimental effects on the landscape and local amenities • Increasing opposition to the location of sites • Low cost landfill is likely to inhibit waste minimisation and recycling • Major landfill tax and compliance and after care liabilities
Mechanical Biological Treatment (MBT)	• Proven technology with numerous reference plants operating on MSW in mainland Europe. However few are now used purely for bio-stabilisation. • Can be modular in design capacity, allowing future expansion if sufficient space on site. • Can produce a stabilised biowaste in the form of compost or soil conditioning material or produce a high calorific fraction (SRF or RDF), to contribute to diversion targets for Biodegradable Municipal Wastes (BMW) • Some potential flexibility in the proportions of the end product that is made (e.g. switch of balance from SRF to soil conditioner), depending on the process configuration • Modular multi stream systems may be suitable to also separately compost kitchen organic wastes, including meat, to comply with the	• Not yet proven within long-term operating experience under the UK regulatory regime • Limited UK third party markets for solid recovered fuels (SRF) and MBT derived soil conditioners at present. Market failure in outlets would result in SRF and compost being landfilled leading to possible failure of LATS diversion targets • An ancillary Energy Recovery Facility (ERF) is required to give guaranteed outlets for any solid recovered fuel (SRF) outputs • Any compost-like fraction resulting from treating residual waste is categorised any waste by the Environment Agency and cannot currently be applied to agricultural land • The amount of BMW stabilisation achieved by different processes is yet to be fully determined. This may present major uncertainties in compliance with LATS targets if outputs are landfilled

Waste Technology	Strengths	Weaknesses
	Animal By Products Regulations • Can recover additional value from the residual fraction, such as metals and low grade aggregates of which some can contribute to BV 82(a) • Provides weight reduction of residual waste via release of process losses such as water and carbon dioxide • Plant design can maximise water efficiency, effluent disposal and odour/dust control • Some highly controlled systems allow for changes in composting conditions to achieve the optimum temperature and moisture levels	• Air emissions are likely to require treatment in bio-filters or combustion units • Can require a large footprint dependant on the technology configuration chosen. Bio-stabilisation systems are larger due to the increased time needed to treat the waste
Anaerobic Digestion (AD)	• Numerous reference plants operating on MSW in mainland Europe for source-segregated wastes, some for mixed waste • Suitable for kitchen organic wastes, including meat. Can comply with the Animal By Products Regulations. Therefore allows food waste to be recycled and potentially used as a soil conditioner if separately processed • Some processes can be configured to generate a number of different outputs, e.g. SRF, biogas or soil conditioner • Surplus electricity generated from AD Biogas is eligible under the Renewable Obligation Certificates (ROCs) scheme, creating additional income, and contributes to national renewable energy targets • Can contribute to BV 82(a), (b) or (c) targets dependant on the quality of the final product • Can be integrated with other waste infrastructure as part of a waste management solution (e.g. MBT and in-vessel composting)	• The technology is relatively under-developed in the UK for mixed residual waste, although mature technology for sewage sludge stabilisation. Not yet proven within long-term operating experience under the UK regulatory regime • Limited third party markets for compost-like outputs or SRF fractions. Digestate sludge will have to compete with other sludge for UK market outlets. Any compost-like fraction resulting from treating residual waste cannot currently be applied to agricultural land • An ancillary Energy Recovery Facility (ERF) is required to give guaranteed outlets for any solid recovered fuel (SRF) outputs • Generally requires some mechanical pre-treatment processing plant for use with residual wastes • The efficiency of mixed waste AD systems will be influenced by the collection of source separated organic waste • May have greater visual impact than some other treatment technologies due to the tall digestion tanks and gas flare stack

Waste Technology	**Strengths**	**Weaknesses**
		• The majority of systems are net users of water and require effluent treatment
Autoclaves (AC) – [also termed Mechanical Heat Treatment]	• Proven on non-MSW applications (clinical waste) • Process sterilises the waste, making storage and transport of outputs easier • Can recover additional value from the residual fraction, such as metals and low grade aggregates of which some can contribute to BV 82(a) • Enhanced removal efficiency for recycling; labels and glue are stripped away from food cans can increase the quality of metal recyclates • Can prepare the waste for treatment in other processes (e.g. anaerobic digestion)	• To date, no commercially operated MSW plants in the UK. Not yet proven under the UK regulatory regime • A pre-treatment system only • Perceived as new technology - some uncertainties about allocation of risks for performance and markets • Limited third party markets (currently) for recovered fibre: either as SRF or as a secondary material for composite building products (e.g. roofing tiles) • An ancillary Energy Recovery Facility (ERF) is required to give guaranteed outlets for any solid recovered fuel (SRF) outputs • Process can have a high energy demand if facility is stand-alone • The water from the process can have a high biodegradable content and requires treatment. Air emissions may also require treatment. • Some materials may be more difficult to recover or recycle due to heat deformation and mixing
Energy from Waste by Incineration	• Proven waste treatment method in the UK. Proven compliance with the Waste Incineration Directive requirements • Suitable for a wide range of wastes, including untreated residual MSW • Can contribute to BV 82(c) target recovery performance. Total diversion of biodegradable input also, providing assured contribution to the LATS targets. Bottom ash can also be recovered and used as secondary aggregate	• Has historically had poor public perception, including concerns over health and atmospheric emissions, which may lead to high planning risk • Produces around 20-25% bottom ash, which requires construction market outlets to avoid landfill • A proportion of ash produced (e.g. the air pollution control residues), is deemed hazardous and would therefore require disposal to specialist landfills or treatment facilities

Waste Technology	Strengths	Weaknesses
	• Potential for energy recovery via electricity or Combined Heat and Power (CHP) schemes, where the CHP may qualify under the Renewable Obligation Certificates (ROCS) scheme for additional income • Recent technology development has made conventional combustion more affordable on a smaller scale • Often smaller footprint than other waste diversion technologies	• Can have a visual impact due to stack height, dependant on facility size and location (although can be mitigated through plant design) • Poor public perception
Advanced Thermal Treatment	• Can contribute to BV 82(c) target recovery performance. Total diversion of biodegradable input also achieved, providing assured contribution to the LATS targets. • Can accept higher calorific value wastes, e.g. SRF • Facilities can be built for smaller tonnage throughputs making them suitable for regional facilities and reduces the required footprint • If treating solid recovered fuels (SRF), gasification type systems may produce less ash compared to traditional EfW systems, or may be able to produce a stable vitrified product • Potential for energy recovery via electricity or Combined Heat and Power (CHP) schemes, and can quality under the Renewable Obligation Certificates (ROCS) scheme for additional income. • May be possible to recover the bottom ash for use as secondary aggregate, depending on technology. • Possibly better public perception that conventional EfW via incineration, but untested in UK planning system	• Immature technology for treating mixed municipal wastes in the UK, although successful trials have been run on clinical wastes • Requirement for some form of waste preparation prior to combustion • Air emissions still require treatment, with the stack height dependant on facility size and location • ATT processes will all produce a gas (usually for energy recovery) and a solid residue (ash, slag or char). The quantity of solid residue will vary between technologies and will require construction market outlets to avoid landfill. • A proportion of ash produced (e.g. the APC residues), is deemed hazardous and would therefore require disposal to specialist landfills of treatment facilities • Process efficiency generally lower than conventional combustion • May encounter planning risks due to public perception associated with combustion technologies
Composting	• Can produce useful product for agriculture, horticulture, land improvement, reinstatement etc	• Requirements for separation and screening if markets are to be secured.

Waste Technology	Strengths	Weaknesses
	• Reduces biodegradable waste from being landfilled and as a result can help reduce the production of landfill gas and leachate • Recycling usually requires less energy than the use of virgin materials • Reduces demand for landfill and other waste management capacity • Peat conservation	• Can require screening to remove contaminants, particularly heavy metals • Some source materials can be unsuitable because of persistent contamination • Requires controlled conditions and careful management to produce a successful end product • Can produce odour and leachate problems if not contained • Health, safety and amenity issues need to be addressed (e.g. compliance with ABP Regulations, bio-aerosols).
Materials Recovery Facility (MRF)	• Enhances levels of recycling • Saves on waste disposal charges • Enhanced public image • Recycling usually requires less energy than the use of virgin materials • Reduces demand for landfill and alternative waste management methods • Creates employment • Can generate revenue through enhancement of product quality	• Can be difficult to persuade manufactures, or suppliers to use recycled materials • Can use more energy in transporting recyclable materials than is saved in the recycling process • Markets for recycled materials need to be developed • Life cycles of wastes need clarification to ensure full benefits from recycling • Health, safety and amenity issues need to be addressed • Financial viability can be highly susceptible to market variations and waste throughput
Transfer Station	• Can reduce vehicle movements and associated environmental impacts • Can reduce waste transportation cost	• Potential dust, odour and vermin problems if site is not well managed • Can have detrimental effects on the landscape