

Appendix C

Alternative Options for Treating Residual Waste

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1 TYPES OF TREATMENT PROCESS

There are three main groups of technology processes that can be considered for treating residual waste:

- Energy from Waste (EfW) – Mass burn incineration
- Advanced thermal treatment - Gasification or pyrolysis.
- Mechanical Biological Treatment (MBT) including autoclaving/steam treatment

1.1 Energy from waste

The most common Energy from Waste (EfW) systems are based on grate technology and are capable of burning waste that has not been pre-treated. Other technologies such as rotary and oscillating kilns are also used with untreated waste. The waste is delivered to the site where it is tipped into a concrete pit. From there it is loaded by grab-crane into a hopper. From the hopper the waste is fed onto the grate, where it burns in an updraft of air blown into the combustion zone by fans from below. Combustion air is also added to the combustion chamber above the grate to burn the volatile gases evolved. Waste continuously enters one end of the furnace and ash is continuously discharged at the other. The hot combustion gases then flow across banks of boiler tubes where heat is transferred to water, generating steam. The steam can be passed through a steam turbine that can be used to drive an electrical generator, may be supplied to heating networks, or in combination as Combined Heat and Power (CHP).

An alternative is fluidised bed combustion (FBC). In fluidised beds the burning fuel is suspended in an upward flowing stream of air. This takes place in a furnace section containing a bed of refractory sand or limestone supported by an air distributor plate or nozzle system. The bed resembles a violently boiling liquid. The refractory sand or limestone bed material is usually present in larger quantities than the waste itself, and this gives it a high thermal mass, which allows operation with waste of highly variable properties.

Although there are examples, grate systems are generally not used for installations with a throughput of less than 100,000 tonnes per annum. Fluidised beds and other technologies tend to be more economical at throughputs below this.

Municipal waste requires some form of pre-treatment before it can be treated in fluidised beds. This pre-treatment of the waste, and the operating principle of the fluidised bed design itself, improves combustion efficiency and may result in reduced pollutant production within the incinerator. However, because the dominant affect on final emissions to air arises from the use of flue gas treatment systems, final emissions to air are generally similar.

There is strong public concern over air quality related health risks. The concerns originated from the relatively high levels of dioxins and furans which were generated by some early combustion plants. Recent legislation and the subsequent design improvements means that the new generation of energy from waste plants are now responsible for less than 4% of the national arisings of these pollutants. Recent studies have shown that the risks to human health from modern energy from waste installations are extremely low.

1.2 Advanced Thermal Treatment

“Advanced thermal treatment” is a term used to describe gasification and pyrolysis systems. Such systems are not as widely applied to waste treatment as direct incineration. The basic

operating principle of these technologies differs from incineration in that oxygen (air) is either not supplied (pyrolysis), or is restricted below the quantity required for full oxidation of the waste (gasification). Both systems generally result in the production of a gas, which may be used as a fuel or, in generally limited circumstances, a chemical product. Depending on the process, other outputs include liquid and/or solid materials. In most cases gasification and pyrolysis of waste is coupled with a subsequent combustion stage from which, as with incineration based energy-from-waste plants, the thermal and/or electrical energy may be recovered. The paragraphs below provide further information about each of these technologies.

Gasification is the conversion of a solid or liquid feedstock into a gas by partial oxidation under the application of heat. Partial oxidation is achieved by restricting the supply of oxidant, normally air. For organic based feedstock's, such as most wastes, the resultant gas is typically a mixture of carbon monoxide, carbon dioxide, hydrogen, methane, water, nitrogen and small amounts of higher hydrocarbons. However, the gas will contain tars and particulate matter, which may need to be removed before the gas is suitable for combustion. The degree of this contamination will depend on the gasification technology used.

Pyrolysis is thermal degradation of a material in the complete absence of an oxidising agent (e.g. air or oxygen). In practice, complete elimination of air is very difficult and some oxidation is likely to occur. Typically the process occurs at temperatures in the range 400-800oC. When applied to waste materials, the action of heat breaks complex molecules into simpler ones. This results in the production of gas, liquid and char. These products can have several uses depending on the nature of the feedstock, however for waste based feedstock's the most likely use is as a fuel for energy generation.

Gasification and pyrolysis are not new technologies; for example, coal gasification has been used since the early 1800s to produce town gas and the first four-stroke engine was run on producer gas in 1876. However, their application to waste feedstock's is still being developed, and they may well be more suitable for treating the Refuse Derived Fuel (RDF) products produced by MBT processes rather than processing residual household waste.

1.3 Mechanical Biological Treatment

Mechanical Biological treatment (MBT)¹ is a term that encompasses a very wide range of technologies, which aim to process waste by a mixture of mechanical and biological separation. The two approaches are:

- Mechanical biological (MBT) – Waste is mechanically sorted followed by composting or anaerobic digestion (AD) of the separated biodegradable fraction.
- Biological mechanical (BMT) – Biological treatment (biological drying through composting) of the waste stream is undertaken before mechanical sorting of the waste.

¹ A more detailed description of MBT processes can be found in a number of publications, such as – “Mechanical Biological Treatment; A Guide for Decision makers. Juniper Consulting, March 2005.

Generally, the outputs from the MBT processes are:

- Recyclable materials such as metals and glass.
- An organic rich fraction that can be composted or treated in AD to produce a compost product/digestate.
- A fuel product which can either be burnt in an on site combustion unit, sent for combustion off-site such as cement kilns, power stations, or treated by gasification to produce a gas which is then burnt to produce electricity.
- Rejects that have to be land filled.

There are three main types of MBT process

1. Production of both a refuse derived fuel (RDF) product and a compost product
2. Production of a RDF product
3. Production of a compost product.

1.3.1 MBT process with compost and fuel production

This type of process initially uses mechanical separation to produce a number of products - an organic rich product for biological treatment, a fuel rich product, recyclable materials and a reject fraction. The fuel rich product is then prepared to be suitable for the market and the organic rich product is biologically processed (composting or AD) to produce a low grade compost product which can be used as a soil conditioner. The ratio between RDF and compost can be varied by changing the size of the screen, e.g. if there is little market for a soil conditioner, then the size of the screens can be reduced to produce more RDF product.

Examples of this type of process in the UK are the plants in Leicester, the Isle of Wight and Neath Port Talbot.

1.3.2 MBT process with fuel production

There are two options for producing just a fuel product from residual waste:

- Processes which use biological treatment to dry the waste
- Processes which use steam to degrade the waste (for example, autoclave based processes)

Biological treatment

Biological mechanical treatment (BMT) is used to dry the waste in order to both make the mechanical separation more effective and also to increase the calorific value of the fuel product. The two principle systems are the Eco-deco process and the Herhoff process. The Eco-deco process will be used by two plants which are due to be constructed in East London.

The process starts by putting the waste into composting vessels where it is composted for about one to two weeks. The main aim of this process stage is to reduce the moisture content. The waste then undergoes mechanical separation to produce ferrous metal (which can be recycled), a fuel product and a reject fraction. The main difference between the Eco-deco process and the Herhoff process is the method of mechanical separation. The Eco-deco process uses screening (the combustible materials are larger than the non-combustible materials) whilst the Herhoff process uses density separation (the combustible materials are lighter than the non-combustible materials). The fuel is then prepared for market.

The reject fraction has a high organic content and could undergo further composting to generate a poor quality compost suitable for landfill cover. However, it is usually landfilled as the most readily degradable materials are lost in the initial composting phase.

Steam treatment

The main type of steam treatment process uses an autoclave system, where waste and steam are fed into a drum together. The combination of water and heat provided by the steam causes the paper and organic materials in the waste to break down and produce a “crumb” type of material which has a maximum particle size of about 50 mm. This process is undertaken in batches and takes about 45 minutes. The processed waste is discharged from the drum and fed into a mechanical sorting circuit which segregates a paper/organic product (RDF), glass, plastic and metal for recycling.

An alternative approach is to use a combination of water and heat rather than steam. The residual waste is initially mixed with water and the heat is provided by warm air. These differences allow the process to operate continuously rather than in a batch mode. Once this stage of the processing has been completed the remaining mechanical sorting circuit is the same as for the steam treatment.

The main advantages of a steam treatment process over biological treatment are:

- The paper/organic RDF product has a higher biomass content (because it contains virtually no plastic)
- There are other potential markets for the paper/organic product
- Glass and plastic can also be separated for recycling

However, this type of process is still being developed.

1.3.3 MBT process with compost production

Processes for composting mixed waste have been in use for many years and there are many different types of composting systems available. Generally, waste is shredded and then fed into the composting container. The waste is actively aerated and moved to enhance the composting process. Following the composting stage, the material is sorted to produce a compost product, ferrous metal, non-ferrous metal, glass and plastic.

2 COMPARISON OF TECHNOLOGIES

There are a number of issues for each of these technologies which should be taken into account. The main issues to consider are:

- The operational status of each technology type - will it be able to process the required amount of waste.
- Markets for the products - if sufficient market capacity cannot be identified, material would need to be landfilled which would increase the overall cost and probably result in failure to meet the Landfill Directive targets
- Emissions from the treatment process
- Public perception of the technology
- Cost (gate fee) for the process.

In addition, other factors, such as visual impact and public perception of the technology also need to be taken into consideration.

2.1 Operational Status

EfW technology is well established and most European countries make more use of waste for energy recovery than the UK. There are around 300 EfW facilities in 18 European countries, treating approximately 50 million tonnes of waste each year. There are currently 13 EfW facilities operating in the UK, of which all but one are conventional systems. The other, an FBC system is deployed in Dundee - incoming waste is pre-sorted before it is fed to a fluidised bed boiler. Whilst the Dundee plant is the only one of its type in the UK, use of fluidised bed systems (with waste throughputs of between 75,000 and 120,000 tonnes per annum) is well established in both Scandinavia and Japan.

Plants for producing both compost and fuel are a well established technologies, and a number of large scale plants are operating in Europe. For example, one supplier has 25 plants processing over 600,000 tonnes of material, per year and another supplier has recently taken orders for a total of 1.4 million tonnes of capacity in Germany (where the first Landfill Directive target has to be met in 2006).

The other technologies (steam treatment, AD and advanced thermal treatment technologies) are less well established, particularly for treating household waste. Although there are a large number of AD plants in operation processing a range of wastes streams, the technology for processing household waste is not yet fully developed (only two AD plants are currently processing household waste in Europe). A number of gasification plants are operating, and although these treat a variety of wastes, no plants are treating large quantities of household waste. A large-scale steam treatment plant was constructed in Australia, but this experienced long-running technical problems with the final treatment stage and has now been closed. However, a number of other pilot scale steam treatment processes are operating, and a planned larger scale unit should produce sufficient fuel to enable larger scale combustion tests to be conducted.

The Waste Implementation Programme (WIP) includes a work stream on new technologies that will address the barriers to the successful development and take-up of new waste management technologies. Although this may result in the development of reliable processes in future, these technologies all have a higher level of risk in terms of operational status than processes which are already well established.

2.2 Markets

Table 1 indicates the types of product that are produced by each type of process technology described in the previous section.

Table 1: Types of products generated by each treatment technology

	Metals	Other recyclables	Compost	Fuel product	Electricity
EfW – Mass burn systems	✓	✓ ¹			✓
Gasification and pyrolysis	✓				✓
MBT – Compost and fuel production	✓		✓	✓	
MBT – Fuel production	✓	✓ ²		✓	
MBT – Compost production	✓	✓	✓		
MBT – Compost/digestate production			✓		✓

1. Bottom ash can be recycled

2. Steam based processes will enable additional recyclables to be recovered

2.2.1 Metal and other recyclables

All processes should enable additional dry recyclable materials to be recovered for recycling. However, whilst thermal treatment will only recover ferrous metal, others technologies such as MBT can also recover both glass and plastic.

The plastic product is a mixture of polymers, which has restricted potential uses. Possible applications include “wood substitute” products, transport packaging, and products in which the use of plastic would reduce weight (for example plastic kerb stones). However, whilst there are a number of potential markets for plastics recovered by MBT plants, the overall size of these markets may not be sufficient to absorb the quantities of plastic if a significant number of MBT facilities were constructed in the UK. Furthermore, the amount of plastic derived from source separation systems is likely to increase due to the growth in kerbside recycling schemes. In addition, this material is likely to be more suitable for markets due to less contamination .

The glass material recovered by some types of MBT plant is a mixed coloured product which should be suitable for aggregate substitute markets. However, it may well require additional processing to remove unwanted contaminants. In addition, it may also have to compete with glass collected through source separation schemes.

Some MBT plants may be able to recover textiles. A possible use for this material is in a geo-textile product which could be suitable for lining landfills. However, further work is required in order to fully assess and develop the market.

2.2.2 Compost

The compost products from MBT type processes will be of a lower quality than those produced from source segregated materials, and thus will be more difficult to market. The potential applications for this material are:

- Brownfield land remediation
- Use on land growing energy crops (e.g. short rotation coppicing)
- As a soil improver in forestry
- Use on verges and amenity land
- Landfill top cover

Some uses for soil improvers and land remediation have been identified. However, although it may not be difficult to identify short-term markets/uses for the compost product, MBT plants will operate for a minimum of 20 years, and there could well be difficulties in identifying longer term markets for the compost products. In addition, markets need to be identified locally as it is not cost-efficient to transport the compost over long distances.

2.2.3 Fuel product

There is an increasing demand for biomass fuels, including refuse derived fuel (RDF) as it may provide various advantages:

RDF is generally cheaper than conventional fuels.

RDF has a calorific value of up to 17 MJ/kg and there is a potential to use it as a substitute fuel if the conditions of the Waste Incineration Directive can be met.

High biomass content RDF may be eligible under the Renewables Obligation which means that there will be a potential income from Renewable Obligation Certificates (ROCs) for electricity generated. However, RDF is at present not able to comply with the requirements for ROCs although the rules are currently being examined and may be relaxed for high biomass content RDF.

Other users of large quantities of conventional fossil fuel (e.g. the cement industry) are considering how to achieve their Climate Change Agreements or how to comply with the EU Emissions Trading Scheme (EU ETS). Substitution of RDF for fossil fuel may be of interest providing the biomass content of the RDF can be demonstrated.

The main issue regarding the use of RDF by cement kilns is the chlorine content; because chlorine weakens the cement, and the cement industry is well aware of the potential liability issues. However, the cement industry estimates that up to 20% of the heat load of a cement kiln could be produced by RDF, and the cement kiln could also burn other wastes such as tyres at the same time.

Power stations will be covered by the Large Combustion Plant Directive (LPCD). This will require them to reduce sulphur emissions by installing flue-gas desulphurisation (FGD) equipment, and they will also have to reduce NOx emissions (one option for achieving this could be to burn a mixture of fuels). Power stations should be able to burn RDF after they have installed FGD equipment, and the burning of more than one fuel may well also reduce NOx emissions.

The main barriers to the use of RDF by power stations are obtaining Environment Agency approval and the financial/investment cost. It is likely that it will take 1 to 2 years to obtain approval to use the fuel from the Environment Agency, and that a further 1 to 2 years will be required for construction and commissioning of new equipment. This is a similar timescale to that required for obtaining planning permission for a MBT plant and then building and commissioning it.

The main potential users of a RDF product may well require the RDF to have as high a biomass content as possible. Thus the market for RDF produced by steam treatment processes may be significantly larger than that for the more conventional processes.

The RDF could also be gasified at the production plant in order to generate electricity. Although an RDF product may be more suitable for gasification than residual household waste, there are still technical issues that need to be resolved for the gasification process.

Other possible uses for the fuel product produced by a steam type process include combining it with slate to make products such as roof tiles, producing biodegradable bags for the compost industry, or using suitable binding agents to produce a product which is similar to MDF. However, these potential uses are only in the early stages of development and thus the potential market size for the products that would be produced has not yet been determined.

2.2.4 Electricity

The EfW technology for generating electricity is well developed. The other types of processes designed to produce electricity are pyrolysis and gasification, but, as discussed earlier, there are still technical operational issues which need to be resolved for these processes.

2.3 Emissions

A waste treatment plant will need to obtain an integrated pollution prevention and control (IPPC) permit before it can start to process waste. This permit covers emissions to air, water, land and sewers, and also covers noise levels. Although the amount of data on emissions from these plants is limited, available data indicates that plants equipped with suitable emission control facilities should be able to limit emissions, particularly to air, to values that are well below the current limits for authorised processes.

There would also be limits on the emissions from combustion of the fuel product.

A significant proportion of both the capital and operating costs for a waste treatment plant is due to the costs for emission control equipment; for example odour control (through the use of bio-filters) at a composting plant. It is estimated that about 50% of the overall capital cost of a EfW plant, and a high proportion of the overall operating costs are due to the emission control equipment.

2.4 Rejects

Although these technologies could process all of the residual waste, it is necessary to consider the amount of rejected material as this will need to be landfilled. Table 2 shows that the amounts of rejects would be highest for plants which include either composting or AD.

Table 2: Proportion of rejects for each technology type

	Estimated Amount of Rejects
Steam treatment	15 - 20%
Gasification/ EfW	0 - 20%
RDF production	0 - 20%
Composting	20 - 30%
Anaerobic digestion	20 - 30%

In addition, these rejects will have a biodegradable content which need to be included when assessing the amount of biodegradable waste landfilled in order to meet the LATs targets.

2.5 Costs

Past evidence has shown that gate fees for a 250,000 tonne EfW plant are about £45 per tonne and the gate fees for MBT plants would be higher, typically ranging between £50 and £60 per tonne depending on the type of process. However, recent changes in the waste industry have indicated that costs for treatment technologies will rise substantially and the gate fees for EfW are more likely around £75 per tonne (250,000 tonne capacity) and MBT technologies may move up towards £100 per tonne.

2.6 Other issues

There are a number of issues which could affect whether a plant would be able to obtain planning permission. Traffic flow is an important factor, and whilst all plants would need to have waste delivered to them, traffic movements relating to the products would be lowest for plants which either produced electricity or were located on the same site as the user of the fuel product.

Visual impact is another factor that needs to be considered. Composting plants would require a larger area than other technologies, and whilst the height of the buildings should be similar for all technologies, plants that produce electricity will tend to need a higher chimney.

In addition, it is important to consider public perception of the treatment technology. Any plant, which produces a fuel product could be seen as another form of thermal treatment, and there has been opposition to the use of waste fuels by cement kilns. There could also be concerns about odours from composting plants.

2.7 Summary of advantages and disadvantages

Table 3 summarises the advantages and disadvantages of each technology. Although there is public opposition to EfW, it is a well established technology and a market for the main product (electricity) is readily available. Some MBT technologies are reasonably well developed, and are operating in other European countries, but markets for the products (fuel and/or compost) may well be limited in the UK. Other MBT technologies, such as steam treatment and gasification, are still being developed, but may have larger potential markets for the fuel product that they produce.

Table 3: Advantages and disadvantages of treatment technologies

Technology	Advantages	Disadvantages
Steam treatment (including Autoclave)	<p>Range of potential markets for the main product</p> <p>A higher proportion of dry recyclable materials can be recovered for recycling</p>	<p>Technology is not yet fully established</p> <p>Markets are currently limited</p>
Gasification	Markets are available for the electricity which is produced.	Technology is not yet proven with household waste.
Production of a refuse derived fuel (RDF) product	The technology is well established in some European Countries	Markets for the fuel product are currently limited in the UK
Composting	Composting is a simple technology and is very well established.	<p>Markets for the compost product will be limited</p> <p>The compost may not be able to be included in calculation of the recycling rate.</p>
Anaerobic Digestion	Markets are available for the electricity that is produced.	<p>Technology not yet well established for household waste</p> <p>Markets for the compost product will be limited.</p>
Energy from Waste	<p>The technology is well established</p> <p>Markets are available for the electricity that is produced.</p>	<p>Public opposition</p> <p>Metal and ash which are recycled do not currently count towards recycling targets</p>