

Appendix 4 - Options for treating residual waste

There are two broad methods for treating residual waste:

- Thermal treatment, including:
 - Incineration with energy recovery (Energy from Waste or EfW);
 - Gasification; and
 - Autoclave.
- Mechanical/biological treatment (MBT)

This appendix briefly describes these technologies, and identifies the main advantages and disadvantages of each technology.

1. TYPES OF PROCESS

1.1 Thermal Treatment

There are two types of incineration-based EfW technologies: a conventional moving grate combustion unit or a fluidised bed combustion unit. The main advantage of the fluidised bed combustion unit is that smaller units can be constructed (less than 100,000 tonnes per year, compared to a minimum of 250,000 tonnes per year for a more conventional system). It is also able to achieve lower emissions. However, the waste will require some form of pre-treatment before it can be combusted.

There is a strong public concern over air quality related health risks. The concerns originated from the relatively high levels of dioxins and furans that were generated by some early combustion plants. The Waste Incineration Directive sets high standards for emissions, and thus the new generation of energy from waste plants have significantly lower emissions than the earlier plants, such as those that were operating in the 1970's and 1980's.

Gasification is a thermal treatment process that breaks down hydrocarbons into a 'syngas' by carefully controlling the amount of oxygen present. The process is well established in some areas, such as in the conversion of coal into town gas. However, operational reliability of the recovery of energy from MSW in the form of a high calorific value gas, for combustion to raise steam or power gas engines, is not yet fully demonstrated¹

There are few large-scale gasification plants in Europe that handle unsegregated MSW, though there are several commercial sites in Japan. Defra is currently funding the demonstration of a limited number of full-scale gasification plants in the UK, which are at various stages of construction and operation.

Autoclaving has been used for many years to sterilise hospital and surgical equipment using the action of steam and pressure. This technology is also in common use for

¹ Pyrolysis and gasification factsheet, Juniper

sanitising some clinical wastes, and for certain rendering processes for animal wastes, prior to sending to landfill. However its application to MSW is a recent innovation and there is limited commercial experience on this feedstock material.

The autoclave process has the following effect on the waste:

- Biodegradable materials, including paper and card, are broken down into a high biomass fibre for which the main use is as a fuel product
- Glass bottles and tins have their labels removed as the glue disintegrates under the action of the heat;
- Plastics are softened, and labels are removed. Certain types of plastics are deformed by the heat, but remain in a recognisable state, whereas other plastics soften completely forming hard balls of dense plastic.

The products produced by the autoclave process are separated into product streams (fibre product, plastic, etc) using well-established mechanical processing techniques (screening, density separation, magnetic separation, eddy current separation). Hand picking may also be used to separate other materials.

1.2 Mechanical Biological Treatment

Mechanical/biological treatment (MBT) encompasses a wide range of technologies aiming to process solid waste by a mixture of mechanical and biological separation. It is not a new technology, and mechanical sorting and biological treatment processes have been used for many years in municipal waste management.

There are six main types of MBT process:

- Plants that incorporate anaerobic digestion to generate biogas for electricity production. Anaerobic digestion also generates a digestate that can be used as a compost product
- Plants that produce a refuse-derived fuel (RDF) product. This can be produced either by biologically drying the waste and then mechanically sorting it to produce a fuel product which contains mainly paper and plastic, or by treating the waste using steam (the autoclave process) to break down the paper and organic materials into a “crumb” product which can be used as a fuel.
- Plants that use a gasification process (the conversion of a solid or liquid feedstock into a gas by partial oxidation under the application of heat) to produce electricity.
- Plants that produce a compost product. These use mechanical separation to produce an “organics rich” product which is then composted.
- Plants that stabilize waste prior to landfill. This was the original concept for MBT plants and uses a composting process to produce a stabilised (low biodegradable content) material which is then landfilled.
- Plants that produce a compost product and/or a stabilized material for landfilling as well as a RDF product

MBT plants can also recover dry recyclable materials such as metal, glass and plastic.

2. COMPARISON OF TECHNOLOGIES

There are a number of risk issues for each of these technologies which have to be considered. The main risk issues are:

- The operational status of each type of technology - will it be able to process the required amount of waste.
- Markets for the products - if insufficient market capacity can be identified, material would need to be land filled which would increase the overall cost and probably result in failure to meet the landfill Directive targets.
- Emissions from the treatment process.
- The 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

Energy from Waste (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 in total each year. It is reported² that Germany, operates 67 EFW CHP plants in municipal heating schemes

The technologies for producing both compost and fuel are well established, and more than 80 plants with capacities of 20,000 TPA or more are operational worldwide: the vast majority, in terms of installed capacity, being in Spain, Italy and Germany³. Of the 8.5million tonnes TPA total installed capacity, 15% is designed to produce fuel as its primary output. A number of authorities in the UK have signed contracts with suppliers of these plants.

The other thermal treatment technologies (steam treatment and gasification) are less well established, particularly for treating household waste. 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.

Although there are a large number of anaerobic digestion plants in operation, and they process a range of wastes, the technology for processing household waste is not yet fully developed, and only two anaerobic digestion plants are currently processing household waste in Europe.

² Distributed or centralised energy-from-waste policy? Implications of technology and scale at municipal level, 2006 Elsevier Press

³ MBT: a Guide for Decision Makers – Processes, Policies & Markets, Juniper

The Waste Implementation Programme (WIP), which will deliver the Government's waste strategy, includes a work stream on new technologies that will address the barriers to the successful development and take-up of new waste management technologies. A number of demonstration plants will be constructed, and whilst this may result in the development of reliable processes which can treat the required level of waste becoming available in the next few years, at present, these technologies all have a higher level of risk in terms of operational status than processes which are already well established.

2.2 Markets

Metal and other recyclables

All processes should enable additional dry recyclable materials to be recovered for recycling. However, whilst some processes will only recover ferrous metal, others should also enable both glass and plastic to be recovered for recycling.

Recovered plastics product is a mixture of polymers, and this restricts the potential uses. Possible uses 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 that would be produced if a significant number of MBT plants were constructed in the UK. A further factor which may reduce the size of the market is that as the amounts of plastic collected by kerbside schemes increases, this material may be more suitable because it would have lower levels of contamination and thus would be more attractive to potential users.

The glass product 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, and it would also have to compete with mixed coloured glass which has been collected through source separation schemes.

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 than products produced from source segregated materials. The potential uses 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.

Fuel product

There is an increasing demand for biomass fuels, including refuse derived fuel (RDF). There are three main reasons for this:

- RDF is cheaper than conventional fuels, and has a calorific value of up to 16 MJ/kg. 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 will be eligible under the Renewables Obligation (RO). This means that there will be a potential income from Renewable Obligation Certificates (ROCs) for electricity generated, but the requirements of the Waste Incineration Directive will apply.
- Other users of large quantities of conventional fossil fuel (e.g. the cement industry) are considering how they can achieve their Climate Change Agreements or how they can comply with the EU Emissions Trading Scheme (EU ETS). Substitution of RDF for fossil fuel will be of interest to these customers, 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; this is 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 NO_x 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 NO_x 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 a minimum of 1 to 2 years will be required 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 (autoclave) processes may be significantly larger than that for the more conventional processes.

The RDF product could be burnt in a suitable combustion unit at the plant in order to generate electricity. However, such units have experienced operational problems.

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

Electricity

There is a well-established market for electricity. Licensed electricity suppliers are required to source 10% of their supplies from renewable sources, and would therefore be favourably disposed towards an EfW operator, if the plant incorporates CHP and is qualified for Renewables Obligation Certificates (ROCs), since a proportion of the energy from such plants is deemed to be renewable⁴. Licensed electricity suppliers will also enter into contracts for the supply of electricity from EfW plants without CHP, and there are 'green energy' companies, such as SmartestEnergy, that specialise in purchasing electricity from EfW generators.

An EfW plant would need to be located within a reasonable distance from a suitably sized grid connection point. As well as the cost of providing the high voltage link, the income from the sale of energy will be offset by payments to National Grid for:

- **Connection:** Connection charges enable National Grid to recover the costs involved in providing the assets that afford connection to the GB transmission system. Connection charges relate to the costs of assets installed for the sole use of an individual User.
- **Transmission:** The Transmission Network Use of system (TNUoS) charge recovers the cost of Installing and maintaining the GB Transmission network required to allow the bulk transfer of power between connection sites and to provide transmission system security. This charge reflects the marginal investment cost associated with transport of electricity.
- **Balancing Services Use of System (BSUoS):** This charge recovers the cost of balancing the system adequately through the balancing mechanism process.

Heat

Heat energy, transported by steam or hot water, typically from a CHP plant, has a range of applications: in industrial processes, horticulture, and in district or commercial/institutional building heating. The market will be limited geographically to within short distances from the CHP plant, due to the cost of transmission and heat losses from the pipelines supplying the energy. The market may also be highly seasonal.

Adding CHP equipment to an EfW plant, would therefore only be considered, if a secure and sufficient market for the heat energy can be assured: either from existing potential users, or by establishing an appropriate 'eco-park' centred around the EfW plant.

There are a number of environmental benefits to be gained from the use of CHP. These are recognised within Government by the provision of a range of financial incentives, including:

- Climate Change Levy exemption

⁴ Conventional EfW plants without CHP are not presently classified as sources of renewable energy

- Business Rates Exception
- Hydrocarbon Oil Duty Relief
- Carbon Allocation under EU-ETS Phase II (Separate CHP sector)
- Access to Enhanced Capital Allowance
- ROCs for EfW CHP.

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 (on which the gate fee is based) for a refuse 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 Residues

Although these technologies could process all of the residual waste, it is necessary to consider the amount of residue material that would be produced as this will need to be land filled. As an example, the following table shows that amounts of residue (as a percentage of the input waste) produced by MBT plants.

	Amount of residue
Steam treatment	15-20%
Gasification	15-20%
RDF production	15-20%
Composting	20-30%
Anaerobic digestion	20-30%

The residual waste will have a biodegradable content, and thus will need to be included in the LATS assessment of the amount of biodegradable waste that is landfilled.

The residues from an EfW plant are fly ash, bottom ash and metals, and these represent about 20-25% of the input waste. The fly ash (which represents a small proportion of the total residue) is classified as a hazardous waste and must be sent to a suitable treatment facility. The bottom ash can be recycled as an aggregate substitute and the metal can be recycled (however recycling of these materials currently can not

be included in the calculation of the household waste recycling rate, though this issue is being reconsidered).

2.5 Costs

The current typical gate fees for these treatment plants are estimated (the lower price is for plants with a larger capacity) to be⁵:

- Energy from waste (EfW) - £60 to £80 per tonne for plants with a capacity of up to 200,000 tonnes per year
- Mechanical/biological treatment (MBT) - £65 to £100 per tonne for plants with a capacity of up to 200,000 tonnes per year plus costs to burn the produced fuel
- Gasification - £55 to £95 per tonne for plants with a capacity of up to 150,000 tonnes per year).

2.6 Other issues

There are a number of issues that might affect whether a plant would be able to obtain planning permission. Traffic flow is an important factor, and while all plants would need to have waste delivered to them, traffic movements relating to the products would be lowest for plants that 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 while the height of the buildings should be similar for all technologies, plants which combust the waste will have a stack that extends above the roof line.

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

3. SUMMARY OF ADVANTAGES AND DISADVANTAGES OF EACH TECHNOLOGY

Table 1 summarises the advantages and disadvantages of each process/technology. Although there is public opposition to energy from waste (EFW) incineration, it is a well-established technology and a market for the main product (electricity) is readily available. If a long-term contract for the use of waste heat from an EfW plant at nearby premises, then the addition of CHP equipment would improve its environmental impact while enhancing its revenue potential. 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

⁵ Annex A of Waste strategy for England 2007.

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 1: Advantages and disadvantages of treatment technologies

Technology	Advantages	Disadvantages
Energy from Waste (EfW) with or without CHP	The technology is well established Markets are available for the electricity that is produced. Sale of heat energy from CHP would have environmental and economic benefits.	Possible Public opposition Metal and ash which are recycled do not currently count towards recycling targets
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.	Markets for the compost product will be limited The compost may not be able to be included in calculation of the recycling rate.
Anaerobic Digestion (AD)	Markets are available for the electricity that is produced.	Technology not yet well established for household waste Markets for the compost product will be limited.
Steam treatment (Autoclave)	Range of potential markets for the main product A higher proportion of dry recyclable materials can be recovered for recycling	Technology is not yet fully established Markets for the dry recyclables are currently limited