Incineration of Municipal Solid Waste

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Department for Environment Food and Rural Affairs

Contents

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Preamble

This Waste Management Technology Brief, updated in 2007, is one of a series of documents prepared under the New Technologies work stream of the Defra Waste Implementation Programme. The Briefs address technologies that may have an increasing role in diverting Municipal Solid Waste (MSW) from landfill. They provide an alternative technical option as part of an integrated waste strategy, having the potential to recover materials & energy and reduce the quantity of MSW requiring final disposal to landfill.

This Brief has been produced to provide an overview of Incineration Technology, which recovers energy from the combustion of MSW. Although not a new technology it can potentially form part of an overall integrated waste management strategy to divert MSW from landfill. Other titles in this series include: An Introductory Guide to Waste Management Options, Advanced Biological Treatment, Mechanical Biological Treatment, Mechanical Heat Treatment, Advanced Thermal Treatment, Renewable Energy and Waste Technologies, and Managing Outputs from Waste Technologies.

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

The prime audience for these Briefs are local authorities, in particular waste management officers, members and other key decision makers for MSW management in England. It should be noted that these documents are intended as guides to each generic technology area. Further information can be found at the Waste Technology Data Centre, funded by the Defra New Technologies Programme and delivered by the Environment Agency (www.environment-agency.gov.uk/wtd). These Briefs deal primarily with the treatment and processing of residual MSW. Information on the collection and markets for source segregated materials is available from Defra and from ROTATE (Recycling and Organics Technical Advisory Team) at the Waste & Resources Action Programme (WRAP).

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

1. Introduction

Municipal Solid Waste (MSW) is waste collected by or on behalf of a local authority. It comprises mostly household waste and it may include some commercial and industrial wastes. Historically, nationally the quantity of MSW has risen year on year[1], presenting a growing problem for local authorities particularly as legislation, now limits (by implication[2]) the amount of mixed MSW that can be sent to landfill, comes into effect, becomes more stringent over time.

One of the guiding principles for European and UK waste management has been the concept of a hierarchy of waste management options, where the most desirable option is not to produce the waste in the first place (waste prevention) and the least desirable option is to dispose of the waste with no recovery of either materials and/or energy. Between these two extremes there are a wide variety of waste treatment options that may be used as part of a waste management strategy to recover materials (for example furniture reuse, glass recycling or organic waste composting) or generate energy from the wastes (for example through incineration, or digesting biodegradable wastes to produce usable gases).

At present more than 62% of all MSW generated in England is disposed of in landfills[3]. However, European and UK legislation has been put in place to limit the amount of biodegradable municipal waste (BMW) sent for disposal in landfills[4]. A key driver for this focus on biodegradable waste is to reduce the uncontrolled release of greenhouse gas emissions to atmosphere. The Landfill Directive also requires waste to be pre-treated prior to disposal. The diversion of this material is one of the most significant challenges facing the management of Municipal Solid Waste in the UK.

The new technologies that are available for residual MSW treatment can be split into three main categories:

- Mechanical and Biological Treatment (MBT)
- Mechanical Heat Treatment (MHT)
- Advanced Thermal Treatment (ATT) – principally gasification and pyrolysis

In addition to these, incineration offers a further option for the treatment of residual MSW and is an already proven and bankable (large scale facilities already in operation) technology in the UK.

Throughout this document, the term ‘incineration’ is used to describe processes that combust waste and recover energy. Sometimes others use the term energy from waste or direct combustion to describe incineration. All municipal waste incinerators in the UK recover energy from waste in the form of electricity and/or heat generation (see Box 1). Energy recovery can also be achieved from different methods of managing waste including:

- ATT - production of electricity and/or heat by the thermal treatment decomposition of the waste and subsequent use of the secondary products (typically syngas)
- Anaerobic digestion – production of energy from the combustion of the biogas which is produced from the digestion of biodegradable waste
- Landfill - production of electricity from the combustion of landfill gas produced as biodegradable waste decomposes.

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

1. Introduction

Box 1 – Energy Generation

Energy recovered from waste can be used in the following ways:

- Generation of Power (electricity)
- Generation of Heat
- Generation of Heat and Power (this is referred to as Combined Heat and Power (CHP)

The energy generation option selected for an incineration facility will depend on the potential for end users to utilise the heat and/or power available. In most instances power can be easily distributed and sold via the national grid and this is by far the most common form of energy recovery.

For heat, the consumer needs to be local to the facility producing the heat and a dedicated distribution system (network) is required. Unless all of the available heat can be used the generating facility will not always be operating at its optimum efficiency.

The use of CHP combines the generation of heat and power (electricity). This helps to increase the overall energy efficiency for a facility compared to generating power only. In addition, as power and heat demand varies a CHP plant can be designed to meet this variation and hence maintain optimum levels of efficiency.

Combustion of MSW results in the release of carbon dioxide (and other greenhouse gases). Part of the MSW is biomass derived material e.g. card, paper, timber which is a source of renewable energy. MSW also contains combustible elements which are fossil fuel derived materials e.g. plastics and are therefore not a source of renewable energy. Fossil fuel-based carbon dioxide contributes significantly towards the greenhouse effect and hence global warming. In the context of sustainable energy generation carbon emitted from biodegradable waste is classed as short-cycle carbon (i.e. the amount given off when combusted equates to that absorbed during its lifetime).

The more efficient the energy generation process, e.g. CHP, the lower the carbon emissions are per unit of energy produced and the greater the energy and carbon benefits. Hence when considering energy recovery, carbon emissions need to be considered in terms of composition of the residual waste stream, the type of energy produced (heat and/or power) and the overall generating efficiency of the facility. The growing importance of climate change means the carbon footprint of waste management needs to be fully considered in selecting technologies. The Environment Agency lifecycle tool (Waste and Resources Assessment Tool for the Environment – WRATE) is aimed at assisting the comparison and assessment of the environmental performance of different waste options. For more information see http://www.environment-agency.gov.uk/wtd/1396237/?version=1&lang=_e

1. Introduction

The purpose of this document is to provide an overview of incineration with energy recovery. This will include information on technologies, UK and European experience, regulatory issues, public perception and social issues and outputs compared to other treatment options listed above.

There are a wide variety of alternative waste management options and strategies available for dealing with MSW to limit the residual amount left for disposal to landfill. This guide is designed to be read in conjunction with the other Waste Management Technology Briefs in this series and with the case studies provided on Waste Technology Data Centre. Further details about incineration and new technologies for MSW featured in this report are available from the Waste Technology Data Centre http://www.environment-agency.gov.uk/wtd. Other relevant sources of information are identified throughout the document.

Cover image courtesy of Project Integra, Hampshire

2. How it works

2.1 Incineration and the Waste Hierarchy

The waste hierarchy sets out the broad options for waste management, with energy recovery from waste being a preferred option to landfill. However, it recognises that prior to energy recovery waste reduction, re-use, recycling and composting are preferred, where appropriate. European experience illustrates that recovery of energy from residual waste (including by incineration) is compatible with high recycling rates. Therefore, both incineration and ATT can form part of an overall waste management strategy but not at the expense of waste reduction or recycling.

The key to striking the right balance lies in early consultation between stakeholders when local waste strategies are being developed, and in suitably flexible facilities and contracts – i.e. that do not 'lock in' fixed amounts of waste should recycling rates increase. In addition, the commercial deliverability of a facility needs to be considered when determining capacities required and contract periods. In mainland Europe, Denmark and the Netherlands divert the most waste from landfill, achieving the highest recycling rates but have a high reliance on incineration to deal with residual waste. Scandinavian countries in particular have a greater acceptance of incineration and the role it plays in delivering renewable, district electricity and heating. In the EU, Austria and Belgium have the highest recycling and incineration rates.

2.2 Waste Incineration Directive (WID)

In the UK, all waste incineration plant must comply with the WID. This Directive sets the most stringent emissions controls for any thermal processes regulated in the EU. The objectives of the WID Directive are to minimise the impact from emissions to air, soil, surface and ground water on the environment and human health resulting from the incineration and co-incineration of waste.

At a European level, the Waste Incineration Directive[5] incorporates and extends the requirements of the 1989 Municipal Waste Incineration (MWI) Directives[6] and the Hazardous Waste Incineration Directive[7]. WID forms a single Directive on waste incineration and has repealed those three Directives since late 2005.

The requirements of the Directive have been translated into the UK through The Waste Incineration (England and Wales) Regulations 2002[8] which came into force on 28 December 2002. The enforcement of the WID is through the Pollution Prevention and Control (PPC) regime, which provides the mechanism by which all major industrial processes are permitted and regulated, with respect to their environmental performance.

The key requirements in the WID for the operation of an incineration plant are as follows:

- a minimum combustion temperature and residence time of the resulting combustion products. For MSW this is a minimum requirement of 850ºC for 2 seconds
- specific emission limits for the release to atmosphere of the following:
  - Sulphur Dioxide (SO_2)

5 Waste Incineration Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste. http://eur-lex.europa.eu/LexUriServ/site/en/consleg/2000/L/02000L0076-20001228-en.pdf

6 Municipal Waste Incineration (MWI) Directives (89/429/EEC and 89/369/EEC)

7 Hazardous Waste Incineration Directive (94/67/EC).

8 The Waste Incineration (England and Wales) Regulations 2002 (SI 2002 No, 2980). See http://www.opsi.gov.uk/si/si2002/20022980.htm

- Nitrogen Oxides (NOx)
- Hydrogen Chloride (HCl)
- Volatile Organic Compounds (VOCs)
- Carbon Monoxide (CO)
- Particulate (fly ash)
- Heavy Metals
- Dioxins
- a requirement that the resulting bottom ash that is produced has a total organic carbon content of less than 3%.

The combustion conditions are required to ensure complete burnout of the waste is achieved. Emission limits to atmosphere are set to minimise environmental and health impacts. The carbon content in the ash represents minimisation of the combustible material and destruction of the waste.

Further information on environmental compliance for incineration plant can be obtained from the Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration, published by the European Commission in August 2006. This document can be accessed via the weblink below.

http://eippcb.jrc.es/pages/BActivities.cfm

2.3 Difference between Incineration & Advanced Thermal Treatment

Both Incineration and Advanced Thermal Treatment (ATT) technologies offer the option of treating residual waste and recovering energy. These technologies are different in how the waste is processed and the energy liberated for recovery, i.e. combustion directly releases the energy in the waste, whereas pyrolysis and gasification thermally treat the waste to generate secondary products (gas, liquid and/or solid) from which energy can be generated.

The main technical differences between Incineration and ATT are presented below. In addition, Figure 1 shows how the pyrolysis and gasification process differs from incineration (direct combustion) in terms of the levels of air present.

Incineration

Incineration involves the combustion of typically unprepared (raw or residual) MSW. To allow the combustion to take place a sufficient quantity of oxygen is required to fully oxidise the fuel. Incineration plant combustion temperatures are in excess of 850°C and the waste is mostly converted into carbon dioxide and water and any non-combustible materials (e.g. metals, glass, stones) remain as a solid, known as Incinerator Bottom Ash (IBA) that always contains a small amount of residual carbon. The direct combustion of a waste usually releases more of the available energy compared to pyrolysis and gasification.

Advanced Thermal Treatment - Pyrolysis

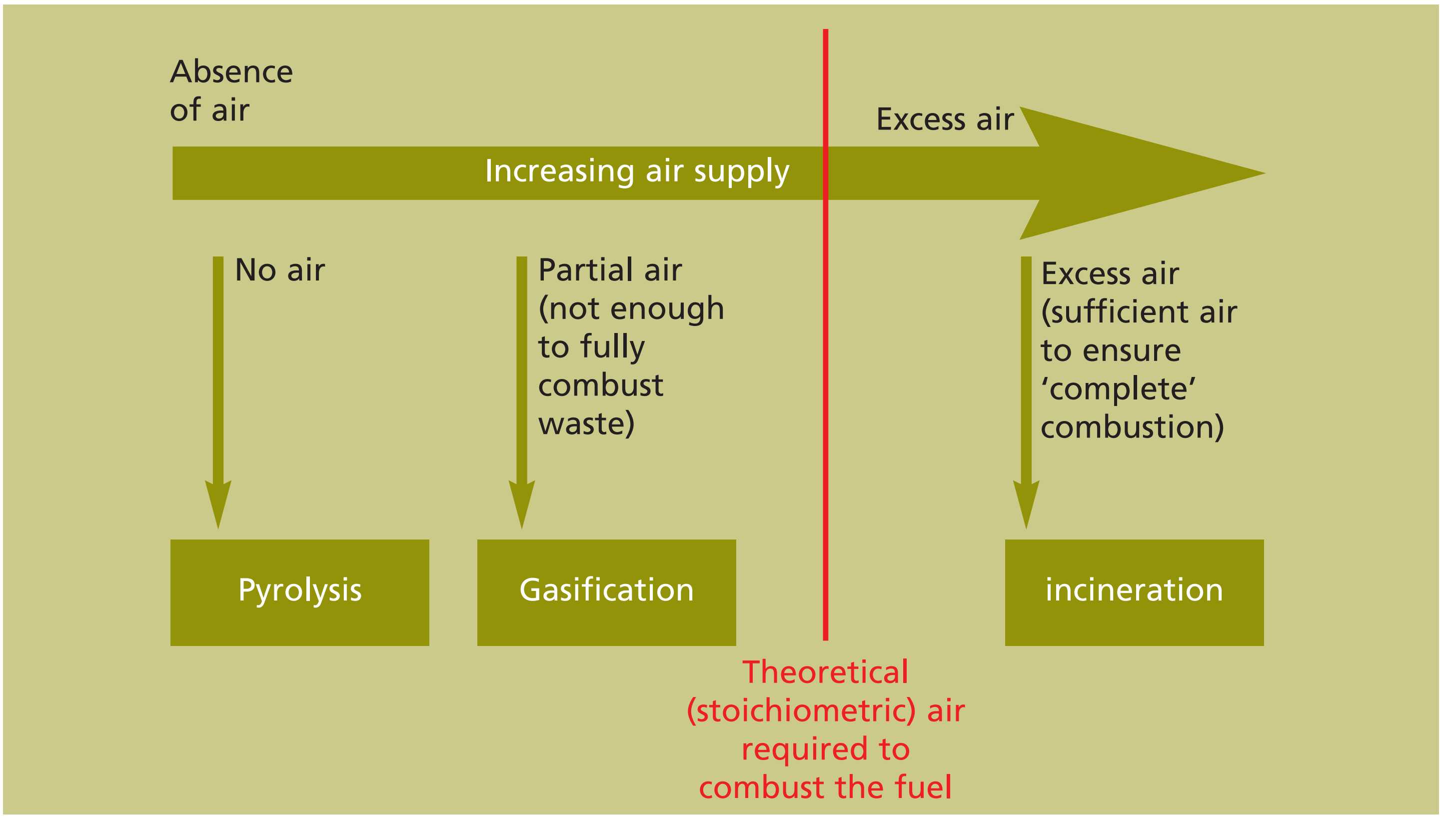
In contrast to combustion, pyrolysis is the thermal degradation of a substance in the absence of oxygen. This process requires an external heat source to maintain the pyrolysis process. Typically, temperatures of between 300°C to 850°C are used during pyrolysis of materials such as MSW. The products produced from pyrolysing materials are a solid residue and syngas. The solid residue (sometimes described as a char) is a combination of non-combustible materials and carbon. The syngas is a mixture of gases (combustible constituents include carbon monoxide, hydrogen and methane) and condensable oils, waxes and tars. The syngas typically has a net calorific value (NCV) of between 10 and 20 MJ/Nm3. If required, the condensable (liquid) fraction can be collected, potentially for use as a liquid fuel or a feedstock in a chemical process, by cooling the syngas. Pyrolysis can be used also for chemical feedstock recycling.

Advanced Thermal Treatment - Gasification

Gasification can be seen as being between pyrolysis and combustion in that it involves the partial oxidation of a substance (see Figure 1). This means that air (oxygen) is added but the amounts are not sufficient to allow the fuel to be completely oxidised and full combustion to occur. The temperatures employed are typically above 650°C. The process is largely exothermic but some heat may be required to initialise and sustain the gasification process. The main product is a syngas, which contains carbon monoxide, hydrogen and methane. Typically, the gas generated from gasification will have a calorific value (NCV) of 4 – 10 MJ/Nm3. The other main product of gasification is a solid residue of non-combustible materials (ash) which contains a relatively low level of carbon.

For reference, the calorific value of syngas from pyrolysis and gasification is far lower than natural gas, which has a NCV of around 38 MJ/Nm3.

Figure 1: Levels of Air (Oxygen) Present During Pyrolysis, Gasification and Combustion Processes for MSW



2.4 Incineration Technology Overview

The actual plant design and configuration of incineration plant will differ considerably between technology providers. However, an incinerator with energy recovery will typically comprise the following key elements:

- waste reception and handling
- combustion chamber
- energy recovery plant
- emissions clean-up for combustion gases
- bottom ash handling and air pollution control residue handling

Waste Reception and Handling

The incineration of MSW can be focused on either combustion of the raw residual waste or of pre-treated feed, for example a Refuse Derived Fuel (RDF). Plant configuration will change according to the feedstock. Typically, the application of incineration in the UK is to take untreated residual MSW. The MSW is normally delivered via a waste collection vehicle and tipped into a bunker where it is mixed. The mixing is required to blend the waste to ensure that the energy input (calorific value of the waste feed) to the combustion chamber is as even as possible.

Box 2 Fuel from mixed waste processing operations

The current prevalent term used for a fuel produced from combustible waste is Refuse Derived Fuel (RDF). The types of technologies used to prepare or segregate a fuel fraction from MSW include Mechanical Heat Treatment (MHT) and Mechanical Biological Treatment (MBT), described in separate Technology Breifs in this series.

A CEN Technical Committee (TC 343) is currently progressing standardisation work on fuels prepared from wastes, classifying a Solid Recovered Fuel (SRF). Preliminary standards have been published in June 2006, and are following an evaluation process, during which the functioning of the specifications will be verified. The technical specifications classify the SRF by thermal value, chlorine content and mercury content. For example, the thermal value class will be based on the number of megajoules one kilogram of recovered fuel contains. In addition, there are many characteristics for which no specific values have been determined. Instead, they can be agreed upon between the producer and the purchaser of SRF.

Along with the standardisation process, a validation project called QUOVADIS (http://quovadis.cesi.it/) on solid recovered fuels is currently being implemented.

It is anticipated that once standards are developed and become accepted by users, then SRF will become the terminology used by the waste management industry. Other terminology has also been introduced to the industry as various fuel compositions may be prepared from waste by different processes. Examples include ‘Biodegradable Fuel Product’ (BFP) and ‘Refined Renewable Biomass Fuel’ (RRBF).

European standards for SRF are important for the facilitation of trans-boundary shipments and access to permits for the use of recovered fuels. There may also be cost savings for co-incineration plants as a result of reduced measurements (e.g. for heavy metals) of incoming fuels. Standards will aid the rationalisation of design criteria for combustion units, and consequently cost savings for equipment manufacturers. Importantly standards will guarantee the quality of fuel for energy producers.

Raw MSW typically has an energy content of 9 - 11MJ/kg, whereas an RDF can have an energy content of 17MJ/kg. Typically where raw MSW is processed into an RDF, the increase in the energy content of the RDF is achieved due to the drying of the waste (removal of water) and the removal of recyclables (glass, metals) and inerts (stones etc), which do not contribute to the energy content of the waste. Therefore, the remaining waste going into the RDF mainly comprises wastes with significant energy content, plastics, dried biodegradable materials, textiles etc.

Within this Brief, RDF will be used as a term to cover the various fuel products processed from MSW. Box 2 describes the development of European Standards for RDF.

Combustion Technology

There are four combustion technologies that can be employed to burn MSW or RDF. A brief overview of the main combustion technologies is presented overleaf in table 1. All of the combustion technologies presented can be designed to meet the technical requirements of the WID, e.g. a minimum temperature of 850°C and a two second residence time for processing MSW.

Energy Recovery

The standard approach for the recovery of energy from the incineration of MSW is to utilise the combustion heat through a boiler to generate steam. Of the total available energy in the waste up to 80% can be retrieved in the boiler to produce steam. The steam can be used for the generation of power via a steam turbine and/or used for heating. An energy recovery plant that produces both heat and power is commonly referred to as a Combined Heat and Power (CHP) Plant and this is the most efficient option overall for utilising recovered energy from waste via a steam boiler.

An incinerator producing exclusively heat can have a thermal generating efficiency of around 80 - 90%; this heat may be used to raise steam for electrical generation at approximately 17 - 30% efficiency[9]. The choice of a steam turbine generator set to produce electricity will limit the upper efficiency based on acceptable boiler temperatures. A modern incinerator producing only electricity from the steam may therefore achieve a maximum electrical generating efficiency of 27%[10], with a typical efficiency range being from 14% to 24%. A recent Defra 'Carbon Balances' report states an efficiency range for electricity only of between 20-27%[11].

9 IPPC Reference document on Best Available Technologies for Waste Incineration, August 2006. Please note that the efficiency quoted is based on the boiler efficiency and not the energy input to the plant and therefore the efficiency does not take account of flue gas losses.

10 Waste Technology Data Centre - Incineration overview http://www.environment-agency.gov.uk/wtd/679004/1491670/?lang=_e

11 Carbon Balances and Energy Impacts of the Management of UK Wastes, ERM and Golder Associates report for Defra, March 2006 www.defra.gov.uk/science/project_data/DocumentLibrary/WR0602/WR0602_4750_FRP.pdf

2. How it works

Table 1: Incineration technologies

Technology	Description
Grate Technologies	**MOVING GRATE** The moving grate furnace system is the most commonly used combustion system for high through-put MSW processing in the UK. The waste is slowly propelled through the combustion chamber (furnace) by a mechanically actuated grate. Waste continuously enters one end of the furnace and ash is continuously discharged at the other. The plant is configured to enable complete combustion as the waste moves through the furnace. Process conditions are controlled to optimise the waste combustion, to ensure complete combustion of the feed. The end of the grate normally passes the hot ash to a quench to rapidly cool the remaining non-combustibles. There are three main sub categories of moving grate combustion systems used for MSW. These are as follows: **The Roller Grate** – this consists of adjacent drum or rollers located in a stepped formation, with the drums rotating in the direction of the waste movement **The Stepped Inclined Grate** – this system uses bars, rockers or vibration to move the waste down each of the grates (typically three) **Inclined Counter-Rotating Grates** – grate bars rotate backwards to agitate the waste and prevent it tumbling down the forward inclined grate until burn out is complete. **FIXED GRATES** These are typically a series of steps (normally 3) with the waste being moved by a series of rams. The first step is a drying stage and initial combustion phase, the second is where the remaining combustion takes place and the third grate is for final carbon burn-out.
Fluidised Bed	The combustion of MSW using a fluidised bed (FB) technique involves pre-sorting of MSW material to remove heavy and inert objects, such as metals, prior to processing in the furnace. The waste is then mechanically processed to reduce the particle size. Overall, the waste requires more preparation than if a moving grate was used. The combustion is normally a single stage process and consists of a lined chamber with a granular bubbling bed of an inert material such as coarse sand/silica or similar bed medium. The bed is 'fluidised' by air (which may be diluted with recycled flue gas) being blown vertically through the material at a high flow rate. Wastes are mobilised by the action of this fluidised bed of particles. There are two main sub-categories of fluidised bed combustors: **Bubbling FB** – the airflow is sufficient to mobilise the bed and provide good contact with the waste. The airflow is not high enough to allow large amounts of solids to be carried out of the combustion chamber. **Circulating FB** – the airflow for this type of unit is higher and therefore particles are carried out of the combustion chamber by the flue gas. The solids are removed and returned to the bed. The use of fluidised bed technology for MSW incineration is limited in the UK, although it is widely applied to sewage sludge. Examples of this technology being used in the UK on pre-sorted waste include the incinerator in Dundee and the new incinerator which is being built at Alington in Kent.
Rotary Kiln	Rotary kilns have wide application and can be a complete rotation vessel or partial rotational type. Incineration in a rotary kiln is normally a two stage process consisting of a kiln and separate secondary combustion chamber. The kiln is the primary combustion chamber and is inclined downwards from the feed entry point. The rotation moves the waste through the kiln with a tumbling action which exposes the waste to heat and oxygen. There is also a proprietary system which oscillates a rotating kiln for smaller scale incineration of MSW with energy recovery. In the UK there is currently one oscillating type rotary kiln incinerator processing MSW, which is in North East Lincolnshire.

For an incinerator that produces combined heat and power (CHP plant), the electrical and thermal generating efficiencies will vary depending on the split between the two forms of energy (heat and power).

An incinerator will typically have a higher net electrical and thermal efficiency than a comparable ATT process[12] that also generates steam for power generation or direct heating. This is mainly due to the energy required to sustain the gasification or pyrolysis process. It is possible that ATT can be used with another power generation technologies other than a steam turbine. For example, the syngas from an ATT could potentially be used in a gas engine or gas turbine (operating in combined cycle mode). Using these power generation options it is possible that higher efficiencies for power generation can be achieved compared to generating steam from burning the syngas and supplying this to a steam turbine.

In contrast, the efficiency of an incinerator for power generation is lower than a large coal fired or gas fired power station. Typically, a coal fired power station will have an efficiency of 33% - 38%; a combined cycle gas turbine (CCGT) power station can have an electrical efficiency in excess of 50%. The reason for the higher efficiencies is a combination of technical issues and the far larger scale of coal and gas fired power plant. Where the energy recovered from an incinerator is used to generate steam for heating, the efficiency is comparable with a boiler fired with natural gas or oil. It is possible that in future the efficiency of electricity generation using incineration will increase given the trend in other solid fuel applications of more severe operating conditions at higher temperature becoming more achievable.

The actual electrical and/or heat output from an incinerator is dependent on the available markets. Electricity can easily be supplied into the national grid and therefore sold and distributed. In contrast heat will need to be used locally to the incinerator. The use of heat will therefore be dependent on identifying and establishing a local need, e.g. a district heating system for buildings/housing and/or supply of heat to a factory for industrial use. The UK does not have a history of district heating systems (with the exception of the system associated with the Sheffield CHP facility) having relied on in part on indigenous fossil fuel reserves, unlike Scandinavian countries where it is common place using locally available resources such as wood and peat. With increasing energy costs, district heating may become financially attractive in the UK.

Emissions Control for Releases to Atmosphere

The emissions limits for specific pollutants that are present in the combustion products (flue gases) from the incineration of MSW are defined in the WID and applied through the PPC Regulations. A PPC permit will be required to operate an incinerator fuelled by MSW in the UK and will set-out a range of conditions including the emission limits for releases to atmosphere.

To meet these emissions limits, the combustion process must be correctly controlled and the flue gases cleaned prior to their final release. The technology supplier for the incinerator plant will define the exact emissions clean-up processes that will be employed. A common approach for control of emissions is as follows:

[12] The Viability of Advanced Thermal Treatment of MSW in the UK, Fitchner 2004. This is based on an incineration plant and ATT plant generating steam for power or heat production at comparable process conditions.

2. How it works

- ammonia injection into the hot flue gases for control of NOx emissions
- lime or Sodium Bicarbonate injection for control of SO_2 and HCl
- carbon injection for capture of heavy metals
- filter system for removal of fly ash and other solids (lime or bicarbonate and carbon)

The control of CO, VOCs and dioxins in terms of their concentration is primarily though correct combustion conditions being maintained. For more information on flue gas cleaning see the IPPC Reference Document on Best Available Techniques for waste incineration.

The clean-up of the flue gases will produce solid residues comprising fly-ash, lime/bicarbonate and carbon. These residues are usually combined (although some systems may separate fly ash and other components) and are often referred to as Air Pollution Control (APC) residues and are classified as hazardous waste, therefore their disposal must be undertaken in accordance with relevant regulations and guidance. Typically, the weight of APCRs produced will be around 2% - 6% of the weight of the waste entering the incinerator.

Bottom Ash Handling

The main residual material from the incineration of MSW is referred to as "bottom ash[13]". This is the residual material in the combustion chamber and consists of the non-combustible constituents of the waste feed. The bottom ash typically represents around 20% - 30% of the original waste feed by weight, only about 10% by volume. The bottom ash is continually discharged from the combustion chamber and is then cooled. The amount of ash will depend on the level of waste pre-treatment prior to entering the incinerator and will also contain metals that can be recovered for recycling.

[13] Sometimes also referred to as 'IBA', Incinerator Bottom Ash

3. Markets and outlets for the outputs

Incineration processes all produce a solid residue (bottom ash). Some systems are also designed with mechanical preparation and sorting equipment to extract recyclables before or after combustion. The table below summarises the key outputs from incineration processes and the following sections address materials and energy recovery.

Table 2: Outputs from incineration technologies

Outputs	State	Quantity by Wt of Original Waste	Comment
Incinerator Bottom Ash (IBA)	Solid residue	20%-30%	Potential use as aggregate replacement or non biodegradable, non-hazardous waste for disposal
Metals (ferrous and non-ferrous)	Requires separation from MSW or IBA	2-5%	Sold for re-smelting
APC residues (including fly ash, reagents and waste water)	Solid residue/ liquid	2-6%	Hazardous waste for disposal
Emissions to atmosphere	Gaseous	Represents ~70%–75%	Cleaned combustion products

3.1 Recovery from Incineration

Materials Recycling

Recyclables derived from either the front end preparation stage of an Incineration plant or metals extracted from the back end of the process (i.e. out of the ash) are typically of a lower quality than those derived from a separate household recyclate collection system and therefore have a lower potential for high value markets. The types of materials recovered from Incineration processes almost always include metals (ferrous and sometimes non-ferrous). However these facilities can help enhance overall recycling levels, although do not contribute to recycling BVPIs currently if material recovery is post-combustion, and enable recovery of certain constituent parts that would not otherwise be collected in household systems (e.g. steel coat hangers, scrap metal etc.).

3. Markets and outlets for the outputs

The IBA produced can then be potentially recycled as a secondary aggregate. However, the recycling of IBA would need to be undertaken in accordance with relevant legislation and guidance[14]. Typically bottom ash is used as fill or in masonry products subject to specific conditions in terms of the deployment of the materials.

The extraction of materials for recycling prior to combustion contributes to recycling targets. For more information on the contribution of Incineration to Best Value Performance Indicators and recycling see section 9 and for the latest developments, see http://www.defra.gov.uk/environment/waste/localauth/perform-manage/index.htm.

Further information on bottom ash use as a secondary aggregate can be found at:

www.aggregain.org.uk/case_studies/2691_performance.html

Energy Recovery

Incineration processes are designed to recover energy from the waste processed by generating electricity and / or heat for use on site and export off site. The useful energy that can be generated from an incineration plant using a boiler to generate steam is presented in table 3. Electricity generated from the biodegradable fraction of waste in an incinerator with good quality heat and power can benefit from support under the Renewables Obligation.

Table 3: Examples of Energy Efficiency for Incineration

Outputs	Efficiency	Use
Heat Only	Up to 80–90%[15] thermal efficiency	Local district heating for buildings (residential, commercial) and or for industrial processes
Electricity	14%-27%*	Can be supplied to national grid for sale and distribution
Heat and Power	Dependent on specific demand for heat and power	Combination of above

* The lower efficiency performance is more typical of older facilities and it is possible that in the future the efficiency of electricity generation using incineration will increase

[14] The Environmental Services Association (ESA) has facilitated an initiative to identify a protocol for the ecotoxicity testing of Incineration Bottom Ash (IBA). The protocol uses a direct testing method on IBA.

[15] IPPC Reference document on Best Available Technologies for Waste Incineration, August 2006. Please note that the efficiency quoted is based on the boiler efficiency and not the energy input to the plant and therefore the efficiency does not take account of flue gas losses.

4. Track record

4.1 UK Experience

The term Incineration for the purposes of this document covers those technologies that directly combust waste and then recover the energy for generating electricity (power) and/or heat.

In terms of its current status incineration accounts for the disposal of 9% of the total MSW produced in England in 2005/6 which equates to approximately 2.8 million tonnes per annum. The UK has 19 incinerators in operation processing MSW. The scale of these facilities in terms of annual waste throughput varies from 23,000 tonnes to 600,000 tonnes. A full list of UK Incineration facilities is presented in Table 4. In addition to the operational facilities presented in Table 4 further incineration plant are being considered or in the process of being commissioned for the UK. Examples of incinerators which are being built or have recently received planning permission include:

- Alington, Kent (500,000tpa). This incinerator is due to come online in 2007. This will produce electricity and have an output of 40MW. Further information can be found at www.kentenviropower.co.uk
- Belvedere, Bexley (585,000tpa) received planning permission in June 2006). This will produce around 66MW of electricity. http://www.coryenvironmental.co.uk/services
- Colnbrook, Slough (400,000tpa) is due for completion and commissioning in 2008. This plant will have an electricity output of 32MW. Further information is available at http://www.viridor-waste.co.uk/index.php?id=141

Table 4: MSW Incineration Plant in UK

Incinerator Plant	Scale	Energy recovery	Established	Website for further information
Edmonton	500,000tpa	Electricity, 32MW	1975	www.londonwaste.co.uk
SELCHP	420,000tpa	Electricity, 32MW	1994	www.selchp.com
Tysesley Birmingham	350,000tpa	Electricity, 25MW	1996	www.onyxgroup.co.uk
Cleveland	245,000tpa	Electricity, 20MW	1998	www.sita.co.uk
Coventry	240,000tpa	Electricity, 17.7MW & Heat	1975	www.cswdc.co.uk
Stoke	200,000tpa	Electricity, 12.5MW	1997	www.mes-e.co.uk
Marchwood	165,000tpa	Electricity, 14MW	2004	www.onyxgroup.co.uk
Portsmouth	165,000tpa	Electricity, 14MW	2005	www.onyxgroup.co.uk
Nottingham	150,000tpa	Electricity & Heat (max 20MW heat)	1973	www.wrg.co.uk
Sheffield	225,000tpa	Electricity, 19MW (max) & 39Heat (max)	2006	www.onyxsheffield.co.uk
Dundee	120,000tpa	Electricity, 8.3MW	2000	www.bbcel.co.uk
Wolverhampton	105,000tpa	Electricity, 7MW	1998	www.mes-e.co.uk
Dudley	90,000tpa	Electricity, 7MW	1998	www.mes-e.co.uk
Chineham	90,000tpa	Electricity, 7MW	2003	www.onyxgroup.co.uk
Kirklees	136,000tpa	Electricity, 9W	2002	www.sita.co.uk
Douglas (Isle of Man)	60,000tpa	Electricity, 6MW	2004	www.sita.co.im
North East Lincolnshire	56,000tpa	Electricity, 3MW & Heat, 3MW	2004	www.groupe-tiru.com
Shetland	23,000tpa	Heat	2000	www.shetland.gov.uk
Isles of Scilly	3,700tpa	No energy recovery	1987	www.scilly.gov.uk

4.2 European Experience

In 2000 there were 304 large scale (where large is assumed to be 30,000 tpa and above) incineration sites, 291 of these process MSW with energy recovery, operating in 18 Western European countries. These sites processed about 50 million tonnes of waste per year which accounted for 50 TWh of energy recovered (40 million tonnes of oil equivalent)[16].

Denmark, France, Switzerland and the Netherlands have the largest installed incineration capacities as a percentage of total MSW generated. The current trend is for larger facilities to realise cost savings per unit of waste processed, most also feature material recovery operations in parallel with the incineration plant.

Incineration is also widely utilised outside of Europe with facilities in operation in most developed countries.

Some descriptive examples of Incineration processes are included here to illustrate the different technologies being promoted for MSW management. The technical details of these and other examples, including mass and energy balances and an analysis of the Strengths, Weaknesses, Opportunities and Threats are included on the Waste Technology Data Centre.

www.environment-agency.gov.uk/wtd

Example of Small Scale Incineration, Shetland

The Shetland and Orkney Isles have entered into a waste management partnership that has resulted in the installation of an incinerator in Lerwick on Shetland. The incinerator processes approximately 23,000 tonnes of MSW per annum. This is the smallest and only MSW incinerator in the UK. The planning for the facility commenced in 1992 and the time required through to commissioning was approximately 8 years, with the plant being operation in 2000. The plant has been designed to meet with all relevant legislation including the WID.

The proposed plant was designed to provide heat which is supplied to both commercial and domestic customers. The thermal efficiency of the incinerator in terms of heat recovered is 80%. The capital cost for the incinerator plant was approximately £10m and the district heating network a further £11.5m. The heat supplied is provided at a competitive rate and has been well received by the end consumers. The cost of installing the heat exchangers per property to allow the heat to be used is between £2,000 and £5,000. The incinerator and heating network provide a significant financial benefit to the Shetland Isles.

Integrating incineration with the proximity principle, Marchwood Hampshire

Hampshire's waste management strategy for MSW includes the development of three incineration plants. The public rejected a single, more economic large scale incinerator in favour of three smaller scale facilities distributed around the county. One of the three incinerators is located at Marchwood and is the focus for this case study.

The Marchwood incinerator is sized to accept 165,000 tonnes of waste per year and has been designed to serve the needs of the south-west of the county. The original plan for developing a waste management strategy which included incineration was put forward in the early 1990s. Planning permission for the incinerator was granted in 2001 and it was commissioned in late 2004. The incinerator generates sufficient electricity to

[16] http://www.assurre.org/downloads/archive/d455ebd0-fdf2-409f-80b6-

export 14MW to the local grid, which is enough power for 14,000 homes. The incinerator is clad in an aluminium dome which is 36m high and 110 metres in diameter. The chimney is approximately 65m high.

The delivery of the incinerator at Marchwood is part of an overall long-term waste management contract which was let by Hampshire Waste Services in 1996, which included new transfer stations, composting plants, material recovery facilities and two further incinerators at Chineham and Portsmouth.

Example of CHP – Switzerland

In the early 1980s Switzerland commenced a step change in the way they managed their municipal waste. The key driver for this was lack of availability and public opposition to landfill. As a result Switzerland is now one of the most advanced countries in the world in waste management, specifically in terms of incineration, biogas fermentation and recycling which is currently set at 46% of the total amount of waste generated.

Since 2000 all non-recycled combustible waste must be incinerated in one of the 29 plants in Switzerland, such as the plant in Thun.

The Thun incineration plant was opened in 2004 in a residential area and in close proximity to thousands of tourists at a capital cost of approximately £82million. The plant is the country's newest facility and has an annual capacity of 100,000 tonnes, providing the 300,000 residents in the area with a third of their electricity consumption requirements, as well as district heating for public sector facilities.

The conversion from steam to electricity and heat takes place in a turbine generator set consisting of an extraction/condensation turbine with regulated low-pressure extraction and ports for district heat output. The plant is designed to produce a maximum of 12 MW of electricity and 25 MW of district heat.

High standards were applied not only to the plant's technology, but to its architecture as well. The design of the plant is said to show a building complex with an air of calm control. Visually it does not hide itself away with excessive screening, in fact the focal point is a glass façade that showcases the technology within and enhances the idea of transparency as a process and of the municipal authority.

5. Contractual and financing issues

5.1 Grants & Funding

Development of Incineration facilities plant will involve high capital expenditure of many million pounds. There are a number of potential funding sources for Local Authorities planning to develop such facilities, including:

Capital Grants: general grants may be available from national economic initiatives and EU structural funds;

Prudential Borrowing: the Local Government Act 2003 provides for a 'prudential' system of capital finance controls;

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

Other Private-Sector Financing: a contractor may be willing to enter a contract to provide a new facility and operate it. The contractor's charges for this may be expressed as gate fees; and

Existing sources of local authority funding: for example National Non-Domestic Rate payments (distributed by central government), credit (borrowing) approvals, local tax raising powers (council tax), income from rents, fees, charges and asset sales (capital receipts). In practice capacity for this will be limited but generally it is through raising taxes.

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

Contractual Arrangements

Medium and large scale municipal waste management contracts, since January 2007, are procured through EU Competitive Dialogue (CD). 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 4ps website.

The available contractual arrangement between the private sector provider (PSP) and the waste disposal authority (or partnership) may be one of the following:

Separate Design; Build; Operate; and Finance: The waste authority contracts separately for the works and services needed, and provides funding by raising capital for each of the main contracts. The contract to build the facility would be based on the council's design and specification and the council would own the facility once constructed;

Design & Build; Operate; Finance: A contract is let for the private sector to provide both the design and construction of a facility to specified performance requirements. The waste authority owns the facility that is constructed and makes separate arrangements to raise capital. Operation would be arranged through a separate Operation and Maintenance contract;

5. Contractual and financing issues

Design, Build and Operate; Finance: The Design and Build and Operation and Maintenance contracts are combined. The waste authority owns the facility once constructed and makes separate arrangements to raise capital;

Design, Build, Finance and Operate (DBFO): This contract is a Design and Build and Operate but the contractor also provides the financing of the project. The contractor designs, constructs and operates the plant to agreed performance requirements. Regular performance payments are made over a fixed term to recover capital and financing costs, operating and maintenance expenses, plus a reasonable return. At the end of the contract, the facility is usually transferred back to the client in a specified condition; and

DBFO with PFI: This is a Design, Build, Finance and Operate contract, but it is procured under the Private Finance Initiative. In this case the waste authority obtains grant funding from Government as a supplement to finance from its own and private sector sources. The PFI grant is only eligible for facilities treating residual waste and is payable once capital expenditure is incurred.

The majority of large scale waste management contracts currently being procured in England are Design, Build, Finance and Operate contracts and many waste disposal authorities in two tier English arrangements (County Councils) are currently seeking to partner with their Waste Collection Authorities (usually District or Borough Councils). Sometimes partnerships are also formed with neighbouring Unitary Authorities to maximise the efficiency of the waste management service and make the contract more attractive to the Private Sector Provider.

Contracts are becoming more 'output' led since contractors increasingly have to build proposals around obligated targets placed on authorities such as BVPIs and landfill allowance targets.

Before initiating any procurement or funding process for a new waste management treatment facility, the following issues should be considered: performance requirements; waste inputs; project duration; project cost; available budgets; availability of sites; planning status; interface with existing contracts; timescales; governance and decision making arrangements; market appetite and risk allocation.

Further guidance on these issues can be obtained from:

- Local Authority funding http://www.defra.gov.uk/environment/waste/localauth/funding/pfi/index.htm
- The Local Government PFI project support guide www.local.odpm.gov.uk/pfi/grantcond.pdf
- For Works Contracts: the Institution of Civil Engineers 'New Engineering Contract' (available at www.ice.org.uk).
- For large scale Waste Services Contracts through PFI and guidance on waste sector projects see the 4ps, local government's project delivery organisation http://www.4ps.gov.uk/PageContent.aspx?id=90&tp=Y

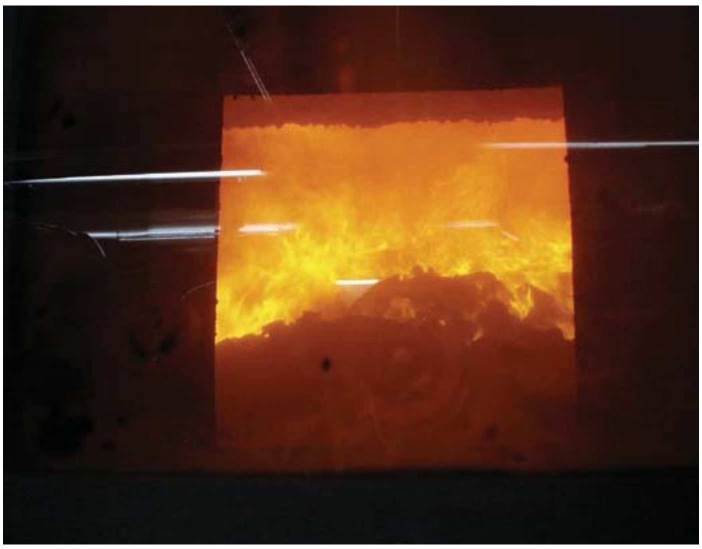
6. Planning and permitting issues

This section contains information on the planning and regulatory issues associated with incineration facilities based on legislative requirements, formal guidance, good practice and in particular drawing on information contained in the Office of the Deputy Prime Minister's research report on waste planning published in August 2004[17].

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 July 2005. Supplementary guidance is also contained within the Companion Guide to PPS 10. Both of these documents can be accessed via the Department of Communities and Local Government (DCLG) website[18].

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[19]. Individual Planning Authorities can set out their own requirements with respect to supporting information and design criteria through Supplementary Planning Documents linked to the Local Development Framework. It is important that prospective developers liaise closely with their Local Planning Authorities over the content and scope of planning applications.

17 http://www.communities.gov.uk/embeddedindex.asp?id=1145711
18 http://www.communities.gov.uk/index.asp?id=1143834
19 http://www.communities.gov.uk/pub/494/BestPracticeGuidanceontheValidationofPlanningApplicationsPDF326Kb_id1144494.pdf

6. Planning and permitting issues

6.2 Key Issues

When considering the planning implications of an incineration plant the key issues that will need to be considered are common to most waste management facilities and are:

- Plant/Facility Siting;
- Traffic;
- Air Emissions / Health Effects;
- Dust / Odour;
- Flies, Vermin and Birds;
- Noise;
- Litter;
- Water Resources;
- Visual Intrusion; and
- Public Concern.

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

6.3 Plant Siting

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.

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

- Incineration processes can be similar in appearance and characteristics to various process industries. It would often be suitable to locate facilities on land previously used for general industrial activities or land allocated in development plans for such (B2) uses;
- Facilities are likely to require good transport infrastructure. Such sites should either be located close to the primary road network or alternatively have the potential to be accessed by rail or barge;
- The location of such plants together with other waste operations such as MBT/MHT and residual waste MRFs can be advantageous in providing a pre-treated waste derived fuel source. The potential for co-location of such facilities on resource recovery parks or similar is also highlighted in PPS 10 and the Companion Guide;
- The potential for export of energy to host users or the national grid should also be a key consideration in the siting of incineration plants; and
- Unlike a number of other new waste treatment processes incineration proposals are likely to have very exacting siting and design requirements. This is due in part to negative public perception but also to the scale of operations which will often require sites that are capable of accommodating large built structures and associated infrastructure.

6.4 Traffic

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

6.5 Air Emissions / Health Effects

In common with any combustion process, combustion of waste results in the release of flue gases to the atmosphere. It is important to ensure that emissions of air pollutants are minimised and/or removed in accordance with the strict emission limits in European Commission Directive 2000/76/EC on the Incineration of Waste. This Directive sets the most stringent emissions controls for any type of thermal process regulated in the EU.

6. Planning and permitting issues

The control of emissions from a waste incinerator starts with the design of the combustion process. This ensures good mixing of waste to provide complete burn-out of waste materials. The flue gases are maintained at high temperature for a specified minimum time, before being rapidly cooled. These stages minimise the formation of potentially harmful substances. Following the combustion stage, the flue gases are normally treated to remove oxides of nitrogen, mercury, dioxins and furans, and acid gases, although specific treatment may not be needed if the in-process controls give the required performance. The air stream is then passed through a bag filter to remove particulate matter. The residual emissions to air from waste incineration processes are discharged from a stack which is designed to provide sufficient dispersion of the low levels of remaining air pollutants.

Waste incineration processes are now designed and operated so that residual emissions of pollutants comply with the emission limits set out in the Waste Incineration Directive (2000/76/EC). Waste incineration facilities need to rely on post-combustion gas clean-up measures such as those described above to achieve the requirements of the Directive. The use of an air filtration system to remove particulate matter from the flue gases results in a fine, dusty waste stream referred to as “air pollution control residues” (or in some cases Flue Gas Treatment residues). This waste stream must be disposed of appropriately.

Emissions of many parameters need to be monitored continuously. This enables process operators to comply with the emissions limits set out in operating permits, which as a minimum reflect those in the Waste Incineration Directive. Some substances, including dioxins, furans and some metals, cannot be measured continuously or it may be prohibitively expensive to do so. Some substances such as dioxins and furans can be continuously sampled, with analysis carried out periodically to give the average amount emitted over a longer period. Emissions of substances which cannot be measured continuously are normally measured periodically under the terms of the operating permit. Routine day-to-day control is achieved by ensuring that surrogate indicators such as combustion temperature, particulate emissions and hydrogen chloride emissions are within the permitted limits.

6. Planning and permitting issues

Incinerator emissions have reduced substantially over the past two decades – most emissions are less than 10% of the level 20 years ago. Because waste incineration has a long operating record, there is a good database of information on emissions and potential health effects compared to other options for managing waste. Emissions from an incinerator typical of those currently operating in the UK (230,000 tonnes per year) are approximately equivalent to[20]:

- Oxides of nitrogen: Emissions from a 7 km stretch of typical motorway
- Particulate matter: Emissions from a 5 km stretch of typical motorway
- Dioxins and furans: Emissions from accidental fires in a town the size of Milton Keynes
- Cadmium: A twentieth of the emissions from a medium sized UK coal-fired power station.

These emissions are approximately equivalent over the same time period. So, emissions of oxides of nitrogen from a typical incineration over a period of an hour are approximately the same as emissions of oxides of nitrogen from a typical motorway 7 km in length over a one hour period.

An independent study[21] on the Health and Environmental effects of waste management is cited by the Health Protection Agency in its position statement on health effects[22]. The independent review and the HPA position statement both found that: "*the weight of evidence from studies so far indicates that present day practice for managing solid municipal waste has, at most, a minor effect on human health and the environment, particularly when compared to other everyday activities*". Adverse health effects have been reported in some studies of populations living around older, more polluting incinerators and in heavily industrialised areas. However, the current generation of waste incinerators result in much lower levels of exposure to pollutants. In particular, there is no evidence for a link between the incidence of cancers, respiratory diseases and birth defects and the current generation of incinerators. The Health Protection Agency emphasises the need for ongoing work to ensure that incinerators do not contribute significantly to ill-health.

6.6 Dust / Odour

Any waste management operations can give rise to dust and odours. These can be minimised by good building design; performing operations under controlled conditions indoors; good working practices; and effective management to suppress dust from vehicle movements. Additionally, incineration processes normally use the air demand of the combustion process to operate the working areas under negative pressure. This means that air is in general drawn into the building through the waste handling area to minimise the risk of dust and odour problems. With these controls in place, waste incineration processes are not normally sources of dust and odour.

6.7 Flies, Vermin and Birds

The enclosed nature of waste incineration 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.

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20 Enviros Consulting Ltd, using Department for Transport Design Manual for Roads and Bridges, Defra review of Health and Environmental Effects of Waste Management Facilities, National Atmospheric Emissions Inventory, and Environment Agency Pollution Inventory

21 http://www.defra.gov.uk/environment/waste/research/health/pdf/health-summary.pdf

22 http://www.hpa.org.uk/chemicals/ippc/incineration_posn_statement.pdf

6. Planning and permitting issues

Effective housekeeping and on site management of tipping and storage areas is essential to minimise the risk from vermin and other pests. In some operations waste heat from the process may be used to bring temperatures in fresh input waste to levels above which flies can live. The use of RDF as a feedstock would reduce this issue relative to raw waste.

6.8 Noise

Noise is an issue that will be controlled under the waste 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 incineration 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;
- steam turbine units; and
- air cooled condenser units

6.9 Litter

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

6.10 Water Resources

In common with most thermal 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 and ground water is linked to the arrangements for delivery of waste and chemicals used for the treatment of flue gases. Under normal circumstances the risks are very low.

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 case studies on the Waste Technology Data Centre include an assessment of water usage.

6.11 Design Principles and Visual Intrusion

Planning guidance in PPS 10 emphasises the importance of good design in new waste facilities. Good design principles and architect input to the design and physical appearance of large scale buildings such as incinerators 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 issues such as:

- Site access and layout;
- Energy efficiency;
- Water efficiency; and
- General sustainability profile

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;

6. Planning and permitting issues

- 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; and
- The number of vehicles accessing the site and their frequency.

Due to the scale of most incineration plant, consideration should be given to the value of investing significant resources into the appearance of the building. Recent examples of incinerators which have become iconic landmark structures include those in the Isle of Man and Marchwood, Hampshire. In mainland Europe, the Vienna incineration plant in the centre of the city is an extreme example..

6.12 Size and Landtake

Table 5 shows the land area required for the building footprint and also for the entire site (including supporting site infrastructure) for incineration facilities. For examples of Advanced Thermal Treatment facilities see the ATT brief in this series.

Table 5: Landtake

TT Facility	Size, tonnes per annum	Buildings Area m^2	Total Landtake Ha	Indicative Stack Height
Medium Sized Moving Grate Technology*	90,000	5850	1.7	65m
Large Moving Grate Technology*	250,000	6,600	4	70m
Large Fluidised Bed Technology#	500,000	70,000	34	80m
Small Oscillating Kiln Technology*	70,000	3,500	4	60m

Source:
* Planning for Waste Management Facilities – A Research Study, ODPM, August 2004
# Based on Kent Enviropower facility in Allington, Kent

For more information on Landtake for specific waste management operations, see the Waste Technology Data Centre.

6.13 Public Concern

Section 7, Social and Perception Issues, relates to public concern. In general public concerns about waste facilities relate to amenity issues (odour, dust, noise, traffic, litter etc). With thermal based facilities health concerns can also be a key perceived issue. Public concern is a material planning consideration and has in part led to previous applications being refused (e.g. Kidderminster). Public concern founded upon valid planning reasons can be taken into account when considering a planning application.

6.14 Environmental Impact Assessment

An Environmental Impact Assessment (EIA) will be required for an incineration facility as part of the planning process.

Whether a development requires a statutory EIA is defined under the Town and Country Planning (Environmental Impact Assessment)(England and Wales) Regulations 1999. The existing additional guidance in DETR circular 02/99 is currently being revised. This new guidance is likely to focus on appropriate criteria for establishing need for EIA and not relate to the general nature of proposals.

For more information on Planning issues associated with waste management options see Planning for Waste Management Facilities – A Research Study. ODPM, 2004 referenced in Further Reading.

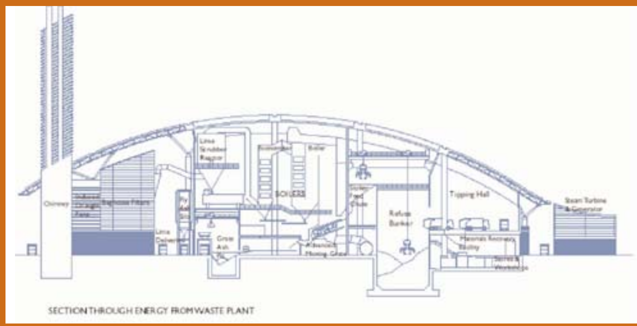
6.15 Licensing/Permitting

Currently, the interpretation of all incineration operations is that they require a Pollution Prevention & Control (PPC) permit. It would be prudent therefore to assume that any facilities will be covered by the PPC Regulations. The Environmental Permitting Programme (EPP) is due to be implemented in April 2008 which will combine waste licensing and permitting systems.

For more information on licensing & permitting see the Environment Agency website[23].

Box 3 shows the key planning issues associated with the Lakeside facility located at Colnbrook, proposed operator Lakeside Energy from Waste Ltd. The planning authority was Slough Borough Council.

Box 3 Lakeside incinerator, Slough



- Planning application for the 400,000 tpa incinerator (termed an Energy from Waste facility, EfW) was combined with the redevelopment of the existing materials recycling facility (MRF) and clinical waste incinerator (CWI).
- The new incinerator is to be sited within the footprint of the existing waste management site; total footprint 3.45 ha
- Site was identified as a protected site in the Berkshire Waste Local Plan but not a preferred location for incineration
- Application submitted August 1999 and approved June 2000; it drew very little public opposition
- Application was subject to a 106 agreement providing wider planning gain
- Full EIA conducted and Environmental Statement included proposals for social and environmental responsibility measures including a visitors centre and management plans for the adjacent lake to enhance ecological approval
- The redeveloped CWI and municipal waste incinerator will share the same emissions stack

[23] http://www.environment-agency.gov.uk/subjects/waste/?lang=_e

7. Social and perception issues

This section contains a discussion of the social and environmental considerations of incineration 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, traffic, landscape) are important considerations when siting any waste management facility. The Planning and Permitting chapter of this Brief provides an estimate of potential vehicle movements.

An incinerator may also provide positive social impacts in the form of employment, educational opportunities and potentially as a cheap source of domestic or industrial heating. Typical employment for an incineration plant of 50,000tpa capacity would be 2-6 workers per shift. The plant would operate on a three shift system, to allow for 24-hour operations. These facilities are also likely to provide vocational training for staff. New facilities may be built with a visitor 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 gaining a higher profile through the media. Many people as a result of greater publicity and targeted education are now embracing the need for waste reduction, recycling and to a lesser extent the need for new waste facilities. The wider perception of waste facilities as a bad neighbour will take longer to overcome. New waste facilities of whatever type are rarely welcomed by residents close to where the facility is to be located.

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

The perception the public has of waste incineration tends to be linked with issues associated with older facilities where the general site management requirements and pollution control measures were not as exacting as they are today.

The emissions from incineration, particular those to atmosphere, must be carefully controlled and monitored. The WID sets the most stringent emissions controls for any type of thermal process regulated in the EU

The current position of the Environment Agency as set out in their Position Statement in 2003 is that "*The Agency is not aware of any studies that conclusively link adverse health outcomes to incinerator releases". In addition to this the Health Protection Agency position statement on incineration found that: "the weight of evidence from studies so far indicates that present day practice for managing solid municipal waste has, at most, a minor effect on human health and the environment, particularly when compared to other everyday activities*".

The control of emissions and public concern relating to releases from incineration to the environment are key issues which need to be considered as part of the assessment process.

8. Cost

The cost of constructing, operating and maintaining Incineration facilities are addressed using a common cost model on Waste Technology Data Centre. Both capital and operating costs are included on specific technologies which may be used for the purposes of indicative comparisons rather than accurate reflections of actual costs.

The capital costs for an incinerator will be dependent on the quality of waste to be processed, the technology employed and its location. Costs will not only comprise those associated with the purchase of the incinerator plant, but also costs for land procurement and preparation prior to build and also indirect costs, such as planning, permitting, contractual support and technical and financial services over the development cycle.

Examples of capital costs for incineration plant are provided on Waste Technology Data Centre www.environment-agency.gov.uk/wtd and are summarised below:

- 50,000tpa £25m
- 136,000tpa £35m
- 265,000tpa £51m

Extreme care is required in utilising cost data such as that provided on the data centre website as it might not be fully inclusive. In addition, site specific criteria need to be taken into account, which are summarised above and actual costs will vary on a case by case basis.

9. Contribution to national targets

9.1 Recycling

Recyclate derived from an Incineration plant processing household waste qualifies for BVPI 82a (Recycling) for any materials recovered prior to the primary treatment reactor. Any materials recovered after the thermal treatment (e.g. metals from the ash), do not count towards BVPI 82a. Equally any ash recycled does not count towards BVPI 82a. The material must pass to the reprocessor (and not be rejected for quality reasons) to count as recycling. It should be noted that some materials may have market limitations due to being derived from a mixed MSW source. For example British Standard BS EN 643 states that 'Recovered paper from refuse sorting stations is not suitable for use in the paper industry.' Although this standard is not legally binding, it is supported by the main trade associations for the paper recycling sector.

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

http://www.defra.gov.uk/environment/waste/localauth/perform-manage/index.htm and

http://www.wastedataflow.org/Documents/BVPI%20FAQs.pdf

9. Contribution to national targets

9.2 Landfill Allowance Trading Scheme (LATS)

The European Landfill Directive and the UK's enabling act, the Waste & Emissions Trading Act 2003, require the diversion of biodegradable municipal waste (BMW) from landfill. Incineration systems will divert 100% of the BMW passing through the thermal process from landfill as the output (char or ash) will not be classified as biodegradable even if disposed to landfill. Up to date information can be obtained from Defra's LATS information webpage:

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

9.3 Recovery

Incineration technologies will contribute towards recovery targets on the tonnage of materials entering the thermal treatment process as all processes are designed to recover energy. See the specific guidance for BVPI 82c (Recovery). The Government has recently increased national recovery targets for municipal waste through the *Waste Strategy for England 2007.* Targets are 53% by 2010, 67% by 2015 and 75% by 2020.

For more details see

http://www.defra.gov.uk/environment/waste/localauth/perform-manage/index.htm

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 currently rises to 15.4% by 2015/16. In essence, the RO provides a significant boost to the market price of renewable electricity generated in eligible technologies.

Electricity generated from the biomass (renewable) fraction of waste in incineration plant with good quality heat and power is eligible for support under the RO. This can provide an important additional revenue stream for a proposed plant, as long as it meets the qualifying requirements. As the value of a ROC is not fixed, the long term value would need to be assessed in detail to determine its overall financial value to the project.

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

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

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

10. Further reading and sources of information

WRATE (Waste and Resources Assessment Tool for the Environment)

http://www.environment-agency.gov.uk/wtd/1396237/?version=1&lang=_e

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

New Technologies Demonstrator Programme Wastetech@enviros.com

Defra New Technologies website

http://www.defra.gov.uk/environment/waste/wip/newtech/index.htm

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

Energy from Waste – A Good Practice Guide, Energy from Waste working group, CIWM, 2003

Refuse Derived Fuel, Current Practice and Perspectives (B4-3040/2000/306517/Mar/E3), *European Commission – Directorate General Environment*, July 2003

Review of Environmental & Health Effects of Waste Management, Enviros Consulting Ltd, University of Birmingham, Open University & Maggie Thurgood. Defra 2004.

AiIE Ltd, 2003, Review of residual waste treatment technologies, Report prepared on behalf of Kingston upon Hull City Council and East Riding of Yorkshire Council

http/www.eastriding.gov.uk/environment/pdf/waste_treatment_technologies.pdf

The Additional Paper to the Strategy Unit, Waste Not Want Not study, 'Delivering the Landfill Directive: The Role of New & Emerging Technologies', Dr Stuart McLanaghan

http://www.number10.gov.uk/files/pdf/technologies-landfill.pdf

Planning for Waste Management Facilities – A Research Study. Office of the Deputy Prime Minister, 2004.

http://www.communities.gov.uk/pub/713/PlanningforWasteManagementFacilitiesAResearchStudy_id1145713.pdf

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

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

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

For large scale Waste Services Contracts through PFI and guidance on waste sector projects see the 4ps, local government's project delivery organisation

http://www.4ps.gov.uk/PageContent.aspx?id=90&tp=Y

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.
Aerobic	In the presence of oxygen.
Animal By-Products Regulation	Legislation governing the processing of wastes derived from animal sources.
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.
Co-combustion	Combustion of wastes as a fuel in an industrial or other (non waste management) process.
Digestate	Solid and / or liquid product resulting from Anaerobic Digestion.
Feedstock	Raw material required for a process.
Floc	A small loosely aggregated mass of flocculent material. In this instance referring to Refuse Derived Fuel or similar.
Gasification	Gasification is the process whereby carbon based wastes are heated in the presence of air or steam to produce a solid, low in carbon and a gas. The technology is based on the reforming process used to produce town gas from coal.
Greenhouse Gas	A term given to those gas compounds in the atmosphere that reflect heat back toward earth rather than letting it escape freely into space. Several gases are involved, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone, water vapour and some of the chlorofluorocarbons.
Green Waste	Waste vegetation and plant matter from household gardens, local authority parks and gardens and commercial landscaped gardens.
Incineration	The controlled thermal treatment of waste by burning, either to reduce its volume or toxicity. Energy recovery from incineration can be made by utilising the calorific value of the waste to produce heat and / or power.
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)	Household waste and any other wastes collected by the Waste Collection Authority, or its agents, such as municipal parks and gardens waste, beach cleansing waste, commercial or industrial waste, and waste resulting from the clearance of fly-tipped materials.

11. Glossary

Pyrolysis	During Pyrolysis organic waste is heated in the absence of air to produce a mixture of gaseous and/or liquid fuels and a solid, inert residue (mainly carbon)
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.
Solid Recovered Fuel	Refuse Derived Fuel meeting a standard specification, currently under development by a CEN standards committee.
Source-segregated/ Source-separated	Usually applies to household waste collection systems where recyclable and/or organic fractions of the waste stream are separated by the householder and are often collected separately.
Statutory Best Value Performance Indicators	Local Authorities submit performance data to Government in the form of annual performance indicators (PIs). The Recycling and Composting PIs have statutory targets attached to them which Authorities are required to meet.
Syngas	'Synthetic 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.