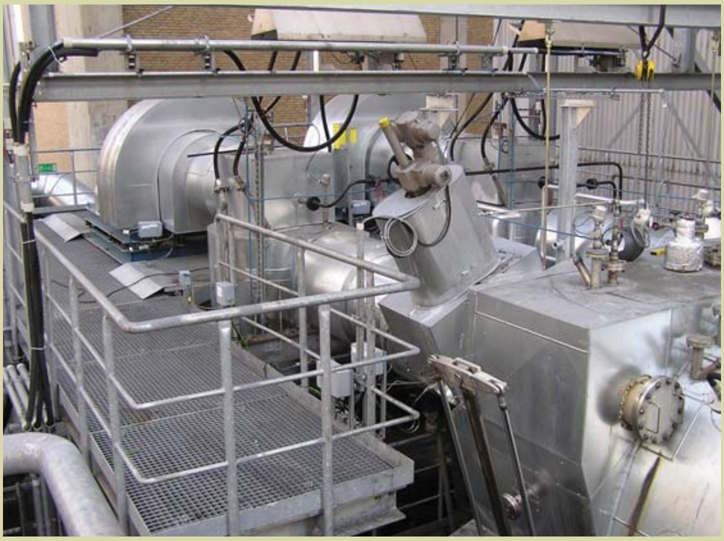
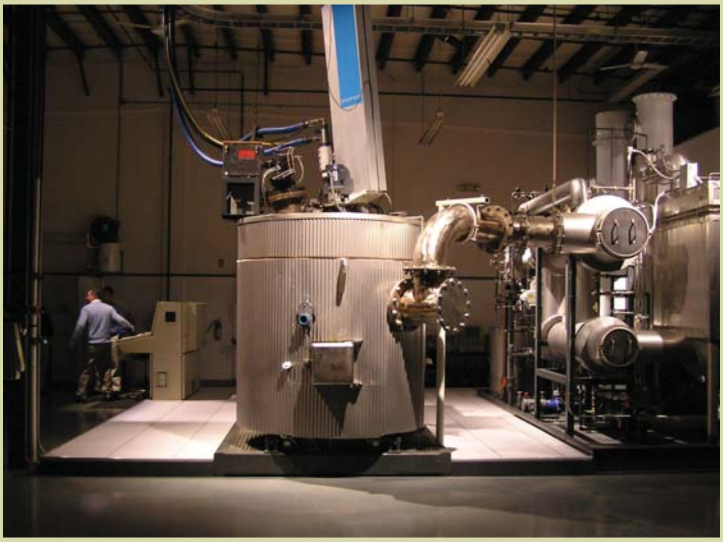
www.defra.gov.uk

Advanced Thermal Treatment of Municipal Solid Waste





defra

Waste Implementation Programme
New Technologies

Contents

This Waste Management Technology Brief is one of a series of documents prepared under the New Technologies work stream of the Defra Waste Implementation Programme. The Briefs are addressing potentially important new technologies which may have an increasing role in diverting Municipal Solid Waste (MSW) from landfill into a more sustainable and integrated waste management alternative, extracting materials and energy from MSW for recovery and reducing quantities remaining for disposal. Other titles in this series include: An Introductory Guide to Waste Management Options; Advanced Biological Treatment; Mechanical Biological Treatment & Mechanical Heat Treatment.

It should be noted that these documents are intended as guides to each generic technology area and for more detailed or specific information on any particular technology, it is recommended that the Defra Waste Technology Data Centre is used as a resource. These Briefs deal primarily with the treatment and processing of unsorted MSW and not source segregated wastes which are addressed by the activities of the Waste & Resources Action Programme (WRAP). Relevant references and sources of further information are cited throughout each document in this series.

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. For further information on new technologies contact the New Technologies Supporter Helpline on 0870 2409894, email: Wastetech@enviros.com

---

Prepared by Enviros Consulting Limited on behalf of Defra as part of the New Technologies Supporter Programme.

We acknowledge support from the Department for Environment, Food & Rural Affairs, the Environment Agency, the Waste and Resources Action Programme, RPS and Be Environmental Ltd.

v.1.0

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. Nationally, the quantity of MSW is currently increasing year on year, presenting a growing problem for local authorities particularly as new legislation, which limits (by implication[1]) the amount of mixed MSW that can be sent to landfill, comes into effect.

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 75% of all MSW generated in England is disposed of in landfills. However, European and UK legislation has been put in place to limit the amount of biodegradable municipal waste (BMW) sent for disposal in landfill. The diversion of this material is currently the most significant challenge facing the management of Municipal Solid Waste in the UK.

There are a wide variety of alternative waste management options and strategies available for dealing with Municipal Solid Waste to limit the residual amount left for disposal to landfill. The aim of this guide is to provide impartial information about the range of technologies referred to as Advanced Thermal Treatment (ATT). These technologies are designed to recover energy (in the form of heat, electricity or fuel) and can contribute to the diversion of BMW from landfill. They are part of a range of new alternatives currently being assessed and investigated through the New Technologies work stream of Defra.

Further details about the new technologies featured in this report are available from Defra's Waste Technology Data Centre:

http://www.environment-agency.gov.uk/wtd

The technologies described in this Brief - Advanced Thermal Treatment - have a limited track record in the UK (and indeed internationally) on MSW. There are many examples of ATT processes that are established as viable and bankable on various waste streams (e.g. biomass, industrial wastes, tyres etc) but a lesser number proven on municipal wastes. The aim of this document is to raise awareness of the technologies available and help remove barriers to the development of appropriate ATT processes in England.

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 Defra's Waste Technology Data Centre. Other relevant sources of information are identified throughout the document.

[1]Targets pertain to the biodegradable fraction

This section comprises an overview of the principles of Advanced Thermal Treatment processes.

Advanced Thermal Treatment

Advanced thermal treatment technologies are primarily those that employ pyrolysis and/or gasification to process municipal solid waste (MSW). It excludes incineration[2] of wastes which is already a mature and well established technology.

The gasification and pyrolysis of solid materials is not a new concept. They have been used extensively to produce fuels such as charcoal, coke and town or producer gas. Charcoal and coke are produced by pyrolysing wood and coal respectively and producer gas is a combustible gas produced by the gasification of coke in the presence of air and steam.

It is only in recent years that such pyrolysis and gasification have been commercially applied to the treatment of MSW. The development of pyrolysis and gasification technologies is in its infancy in the UK but large scale plants have been built and are in operation in Europe, North America and Japan.

Advanced thermal treatment plant

Difference between Pyrolysis, Gasification and Incineration

There are a variety of differences promoted to differentiate advanced thermal treatment from traditional incineration technologies. One distinction is that smaller scale facilities are being marketed for treatment of MSW with some ATT processes than the scale typical of incineration. It is the difference in scale and size that allows the local use of both heat and electricity produced, and the process differences are described below. Pages 13 to 16 discuss planning and public perception aspects of ATT .

Established Thermal Treatment - Incineration

Incineration usually involves the combustion of unprepared (raw or residual) MSW. To allow the combustion to take place a sufficient quantity of oxygen is required to fully oxidise the fuel. Typically, incineration plant combustion (flame) temperatures are in excess of 850°C and the waste is converted into carbon dioxide and water. Any non-combustible materials (e.g. metals, glass) remain as a solid, known as Bottom Ash, that contains a small amount of residual carbon.

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 temperature required. Typically, relatively low temperatures of between 300°C to 800°C are used during pyrolysis of materials such as MSW. The products produced from pyrolysing materials are a solid residue and a synthetic gas (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, methane and a broad range of other volatile organic compounds). A proportion of these can be condensed to produce oils, waxes and tars. The syngas typically has a net calorific value (NCV) of between 10 and 20 MJ/Nm^3. If required, the condensable fraction can be collected by cooling the syngas, potentially for use as a liquid fuel.

[2]Incineration of MSW in the UK always involves some form of energy recovery, either in the form of electricity generation and/or heat recovery. As such it is also commonly termed Energy from Waste. Mass burn incineration is another term used to refer primarily to large scale plant burning untreated waste. In this document we will refer to 'incineration' to distinguish from Advanced Thermal Treatment.

Advanced Thermal Treatment - Gasification

Gasification can be seen as between pyrolysis and combustion in that it involves the partial oxidation of a substance. This means that 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 750°C. The main product is a syngas, which contains carbon monoxide, hydrogen and methane. Typically, the gas generated from gasification will have a net calorific value (NCV) of 4 - 10 MJ/Nm³. The other main product produced by 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.]

ATT Technology Overview

The actual plant design and configuration of ATT facilities will differ considerably between technology providers. However, an ATT plant will typically consist of the following key elements:

- Waste reception, handling and pre-treatment;
- Thermal treatment reactor;
- Gas and residue treatment plant (optional);
- Energy recovery plant (optional); and
- Emissions clean-up (see page 13).

Waste Reception, Handling and Pre-treatment

The pyrolysis and gasification process is focused on treating the organic based materials present in MSW (e.g. paper, plastics, card, putrescible waste, green waste). Therefore, non combustible materials and recyclables, (typically metals and glass) may be removed prior to the thermal treatment reactor stage. In addition and depending on the technology employed, the feed material might require processing to remove excess moisture, and shredding to reduce the size.

It is the preference (for most ATT processes) to treat only pre-processed MSW that makes these systems appropriate to be integrated into a wider municipal waste management strategy. ATT processes may for example be used in conjunction with sorting technologies such as those employed in Mechanical Biological Treatment plant (MBT - see separate Brief, in this series). Some MBT plant are designed to produce a fuel stream (primarily composed of paper, card and plastics) as one of the outputs from the process. This is commonly referred to as refuse derived fuel or RDF (see Box 1). This may be more amenable to processing in an ATT plant rather than raw MSW.

Refuse Derived Fuel

Box 1 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/ segregate a fuel fraction from MSW include many of the MBT and Mechanical Heat Treatment processes described within another Brief 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). It is anticipated that once standards are developed and become accepted by users, 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).

Within this Brief, refuse derived fuel is used as a term to cover the various fuel products processed from MSW.

Thermal Treatment Reactor

The primary thermal treatment, whether pyrolysis or gasification, will produce syngas and solid residue. The composition of the syngas and solid residue will depend on the process conditions employed, which include operating temperature, oxygen level, heating rate and residence time in the reactor.

The main types of thermal treatment units available, their application and operating conditions are summarised in Table 1. [There are also other factors influencing the process such as direction of gas flow (e.g. horizontally or vertically)].

Table 1 : Thermal Treatment Reactors

Reactor	Typical Application	Operating Conditions
Rotating Kiln	Pyrolysis	Typically operate at low temperatures of around 400 - 600°C. The unit can accommodate large size feed material (200 mm). The kiln is heated externally and waste is fed in from one end of the kiln which slowly rotates creating a tumbling action. This mixes the waste and ensures contact with the heating surface and gases inside the kiln.
Heated Tube	Pyrolysis	The tubes are heated externally and temperatures as high as 800°C are used. The process can accommodate large size feed material. The waste passes through the tube at a set speed to ensure the pyrolysis process is complete.
Surface Contact	Pyrolysis	Small size feed material required and therefore significant pre-treatment is necessary. The process operates at high temperatures and the small size of the feed gives high heating rates. The application of this technology is to maximise the rate of pyrolysis.
Fluidised Bed	Gasification	Fluidised bed technology may be used for gasification or combustion processes. The bed is a mass of particles (typically alumina) that has similar characteristics to a moving fluid. This is achieved by blowing hot gases through the bed of particles. This system provides good mixing and heat transfer to the incoming waste. Waste is pre-treated to remove large sized material. This technology is well suited to the gasification of Refuse Derived Fuels.
Fixed Bed	Gasification	There are a range of different reactor types that come under this heading. A typical example is a grate system where the feed passes along the grate and hot gases pass through the bed of waste heating it.

Gas and Residue Treatment

Solids will inevitably be discharged from the process. These solids include metals together with carbon. In the case of gasification, the level of carbon is small; in pyrolysis it is significant. Larger particles of solids in the thermal treatment reactor are usually discharged as bottom ash. Lighter ash is usually collected when the gas is separated with the use of cyclones and ultimately filters. In addition, volatile metals such as lead, tin, cadmium and mercury will be carried in the gas until such point that the gas is cooled for them to be sufficiently condensed.

Energy Recovery/Utilisation of Syngas

One of the potential benefits of pyrolysis and gasification is that the syngas can be used in a number of different ways.

In terms of producing energy, the most common configuration is to burn the syngas in a boiler to generate steam. The steam can then be used to generate electricity by passing it through a steam turbine and, if there is a demand local to the plant, for heating. Using the heat in addition to generating electricity improves the overall energy efficiency of the system significantly.

The syngas can also be used to fuel a dedicated gas engine. A syngas derived from a very well run gasifier, or which has been further processed for example by reforming, may be suitable for use in a gas turbine. Running these types of plant on syngas is still in its infancy and would require cleaning and cooling prior to use. However, using a gas engine or gas turbine could increase efficiencies for electricity generation. This is of particular relevance if a Combined Cycle Gas Turbine (CCGT) or Combined Heat and Power (CHP) configuration is used (see Table 2). Whilst high efficiencies can be achieved using gas engines, the highest efficiencies can only be reached using a high calorific value gas. Efficiencies should be checked if using a lower calorific value gas.

To minimise costs for energy generation, the ATT plant could be located adjacent to an existing power plant and the syngas transferred to it. This would also provide benefits if the existing plant has a higher efficiency than a standalone unit. A key issue that would need to be resolved to allow the transfer of the syngas to an adjacent power plant is whether it would need to comply with the Waste Incineration Directive (WID). If the Directive covered the power plant then this could require major improvement works to the abatement system for controlling emissions and therefore make such an option less attractive or entirely unviable. Early implementation of the WID and Large Plant Combustion Directive would in almost all cases outweigh any potential advantages to the operator of the power plant.

In addition to using the syngas to produce energy, it could also be used as a chemical feedstock. This offers a further option for utilising the syngas but would require the treatment plant to be local to the end user, in order to be a practicable solution. This would require very high gas cleanliness; pollutants, notably sulphur and halogens, may need to be removed prior to combustion of the gas. The reduced gas volumes involved in cleaning the combusted gas rather than the combustion gas gives a financial advantage to the process. Alkalis such as lime and sodium hydroxide are the favoured reagents for removal of the halogen streams. Sulphur can be removed by a variety of routes, largely dependant on the initial concentration (ranging from absorption to the Klaus reaction).

For reference, a summary of the potential net electrical generating efficiencies for new build thermal treatment plant employing various energy recovery options is presented in Table 2. For comparison, the performance of a new mass burn incinerator is also provided. Table 4 also includes examples of efficiencies from specific processes.

Table 2 : Potential net electrical generating efficiencies

Energy Systems	Efficiencies of Pyrolysis/Gasification Treatment Plant	Efficiencies of Incinerator
Steam Boiler and Turbine	10% - 20%	19 - 24%
Gas Engine	13% - 28%	n/a
Combined Cycle Gas Turbine	30%	n/a
Co-firing in existing power plant	Up to 27%	n/a

Case Studies

Some descriptive examples of ATT 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 SWOT analysis of the strengths, weaknesses, opportunities and threats are included on the Waste Technology Data Centre[3].

Waste Gen (Tech Trade) Hamm Germany

This is a pyrolysis plant. It processes a pre-prepared RDF to produce a syngas that is immediately burnt in a dedicated burner in an otherwise coal fired power station boiler. The resulting char after recovery of metals using magnets, and aggregate using a ballistic separator, is fed into the station coalbunkers. Fuel is delivered to the plant in bales or bulk form, from a range of RDF producers. The fuel is conveyed to the two rotary kiln pyrolyser units (20m in length x 2.8m in diameter). Natural gas burners heat the pyrolysis drums.

The two pyrolysis drums replace 10% of the fuel input to a coal fired 330MWe generating set. The RDF is regarded as a fuel (at present in the UK it is classified as waste) and the power station is not Waste Incineration Directive compliant.

KBI Waste & Energy Solutions GmbH

This is a Mechanical & Biological Treatment (MBT) plant followed by an oxygen blown 'down draught' gasifier. The purpose of the waste pre-treatment and the gasifier is to produce a gas of a quality and consistency such that the power plant can safely and reliably operate to a defined efficiency and emission limits.

Received waste is dried in a rotating compost drum and recyclates are removed. The waste then passes to a feed preparation area where additives such as coke, (typically 17%) and limestone are introduced prior to gasification.

Oxygen is added at several points down the gasifier progressively raising the temperature towards the maximum, normally 1500°C.

Additional feeds of steam and natural gas are used so as to control the composition of the produced gas. The gas is burned in a conventional gas turbine set and the exhaust gas from the turbine is used to raise steam. Some of the steam/electricity is used by the process with the excess available for export.

GEM, Graveson Energy Management, Romsey, Hampshire, UK

This process uses fast pyrolysis of a Refuse Derived Fuel (RDF see Box 1) to produce a gas suitable for burning or powering an engine. The essential principle behind the process is to rapidly heat the feed to around 820°C, in the absence of oxygen and hence induce rapid pyrolysis. To do this conventional RDF floc has to be ground such that one major dimension of each RDF particle is less than 2mm. The ground floc then has to be dried to 5% moisture content prior to feeding into the pyrolyser. The pyrolyser consists of a large vertical steel cylinder heated on its outside surface. A close fitting cylindrical drum is suspended and rotated within this cylinder. The RDF is fed at the top of the cylinder and by falling through the gap between the cylinder and drum, is rapidly heated. Within a couple of seconds the RDF has been pyrolysed. Char is separated from the gas in a cyclone. The gas stream is cooled and scrubbed to remove acid gases. The cleaned gas is then fed to a spark ignition engine generator set. Waste heat from the pyrolyser heater, the engine exhaust, engine cooling and the produced gas cooler is collected and integrated with the local heat requirements, hence giving a combined heat and power system.

Summary

This section explains that advanced thermal treatment processes are primarily pyrolysis and/or gasification based. ATT plant, as highlighted by case studies, are capital intensive facilities (also see page 17) and have a design life of 15 - 25 years. Rigorous evaluation of the technology is essential to reduce any operational risks when processing the anticipated feedstock. Over this timescale the composition of waste is likely to alter and the process selected should be robust or flexible enough to treat varying calorific values and compositions of waste feedstock.

[3] www.environment-agency.gov.uk/wtd

Markets for the Ouputs

ATT processes will all produce a gas (usually for energy recovery) and a solid residue (ash or char). Some systems are also designed with mechanical preparation and sorting equipment to extract recyclables. Table 3 summarises the key outputs from ATT processes and the following sections address materials and energy recovery.

Table 3 : Examples of outputs from ATT processes

Ouputs	State	Potential Markets
Slag	Solid, fused	Aggregate
Ash	Un-fused residue	Aggregate replacement, metals can be separated
Flue Gas Treatment residue	Solid, powder/sludge. Invariably a hazardous waste; some potential for neutralising waste acids	Specialist disposal or treatment potential use in chemical treatment works (e.g. neutralising acid waste)
Syngas	Gaseous	Heat or power generation/fuel/some chemical application
Condensate*	Liquid	Fuel/chemical application
Char	Solid	Hazardous waste but could be used as coal replacement in certain combustion applications or as a gasifier feedstock

* care needs to be taken with the chemical composition of this and the hazards associated with it

The following section summarises some key issues with regard to these outputs.

Recovery from ATT

Materials Recycling

Recyclables derived from either the front end preparation stage of an ATT 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 generally have a lower value. The types of materials recovered from ATT processes almost always include metals (ferrous and non-ferrous), usually from the front end of the process. Metal removal can help enhance overall recycling levels and enable recovery of certain constituent parts that would not otherwise be collected in household systems (e.g. steel coat hangers, paper clips etc.).

Pyrolysis plant produce a bottom residue that contains significant amounts of carbon. This will need to be disposed of to landfill, or treated further to reduce the carbon content for example by gasification or combustion. If treated further the final bottom residue could then be recycled as a secondary aggregate. Gasification tends to produce a bottom residue which has a lower carbon content and has usually been melted or fused, and this could therefore be recycled as aggregate. The recycling of bottom ash would need to be undertaken in accordance with relevant legislation but is likely to be of equivalent or potentially better quality than incinerator bottom ash, which is currently recycled in aggregate applications.

Char from pyrolysis process

For more information on the contribution of ATT to Best Value Performance Indicators and recycling see Chapter 9 and for the latest developments, see the Defra website[4] or contact the Supporter Helpline tel. 0870 2409894 Wastetech@enviros.com

Energy Recovery

ATT processes are designed to recover energy from the waste processed, either in the form of fuel production (liquid or gas), or combusting the syngas to generate electricity and/or heat for use on site and export off site. Examples of energy recovery from case studies are included on the Waste Technology Data Centre. Energy recovery may qualify for renewable energy incentives, in the form of Renewables Obligation Certificates (ROCs), see Contribution to National Targets section.

It should be noted that the processes using RDF will have already incurred energy usage in the preparation of the fuel and this prepared material will have a higher calorific value than raw MSW.

For more information on the contribution of ATT to Best Value Performance Indicators see page 18 and for the latest developments, see the Defra website[4] or contact the Supporter Helpline tel. 0870 2409894 Wastetech@enviros.com

[4] http://www.defra.gov.uk/environment/waste/localauth/index.htm

Track Record

Whilst ATT technologies are established technologies for the treatment of certain specific waste streams, it is only in recent years that such pyrolysis and gasification have been commercially applied to the treatment of MSW. The prime drivers in the UK for the development of these technologies are increasing landfill costs and the implementation of the Landfill Directive.

The development of pyrolysis and gasification technologies for MSW is in its infancy in the UK but commercial scale plant have been built and are in operation in Europe, North America and Japan.

Examples of Advanced Thermal Treatment plant in the UK and overseas are included in Table 4.

Table 4 : ATT Plant

Manufacturer	Primary Technology	Country	Operational	Capacity, tpa	Feed
Compact Power	Tube Pyrolysis	UK - Avonmouth	2001	8,000	Clinical Waste
Energos	Grate Gasification	Norway	1997	10,000	Industrial and Paper Wastes
Energos	Grate Gasification	Norway	2000	34,000	MSW
Energos	Grate Gasification	Norway	2001	36,000	MSW and Industrial Waste
Energos	Grate Gasification	Norway	2002	70,000	MSW and Industrial Waste
Energos	Grate Gasification	Norway	2002	37,000	MSW
Energos	Grate Gasification	Germany	2002 Commissioning	37,000	MSW and Industrial Waste
Energos	Grate Gasification	Germany	2005 Commissioning	80,000	MSW, Commercial, Industrial
Energos	Grate Gasification	Sweden	2005	80,000	Municipal and Industrial Waste
Enerkem/Novera	Fluidised Bed Gasification	Spain	2002	25,000	Plastics
FERCO	Fluidised Bed Gasification	USA	1997	165,000	Biomass
FERCO	Fluidised Bed Gasification	UK - Winkleigh Devon	Planning	100,000	Biomass
Foster Wheeler		Finland	1998	80,000	Mix waste
GEM	Fast (ablative) Pyrolysis	UK - Bridgend	Not yet operational	60,000	Pre-sorted MSW / RDF
Mitsui Babcock	Rotary Kiln Pyrolysis	Japan	2000	80,000	MSW
Mitsui Babcock	Rotary Kiln Pyrolysis	Japan	2002	150,000	MSW
Mitsui Babcock	Rotary Kiln Pyrolysis	Japan	2002	50,000	MSW
Mitsui Babcock	Rotary Kiln Pyrolysis	Japan	2003	95,000	MSW
Mitsui Babcock	Rotary Kiln Pyrolysis	Japan	2003	75,000	MSW
Mitsui Babcock	Rotary Kiln Pyrolysis	Japan	2003	60,000	MSW
Thermoselect	Tube Pyrolysis	Germany	1999	225,000	Domestic and Industrial Wastes
Thermoselect	Tube Pyrolysis	Japan	1999	100,000	Domestic and Industrial Wastes
Thermoselect	Tube Pyrolysis	Japan	2003	50,000	Industrial Wastes
Techtrade/Wastegen	Rotary Kiln Pyrolysis	Germany	1984	35,000	RDF
Techtrade/Wastegen	Rotary Kiln Pyrolysis	Germany	2002	100,000	Domestic and Industrial Wastes

Grants & Funding

Development of ATT plant will involve capital expenditure of several million pounds. There are a number of potential funding sources for Local Authorities (LA) 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 new 'prudential' system of capital finance controls;

PFI Credits and Private Sector Financing: under the Private Finance Initiative a waste authority can obtain an annual subsidy from central government through a Special Grant;

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

Other 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 there will be limited opportunity to take advantage of these.

Contractual Arrangements

Medium and large scale municipal waste management contracts are usually procured through the negotiated procedure of the Official Journal of the European Union (OJEU) process.

The 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 Council owns the facility that is constructed and makes separate arrangements to raise capital. Operation would be arranged through a separate Operation and Maintenance contract;

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, Build and Operate Contract but the contractor also provides the financing of the project. The contractor designs, constructs and operates the plant to specified 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 funding for future payment obligations from Government as a supplement to finance from its own and private sector sources.

The majority of large scale waste management contracts currently being procured in England are Design, Build, Finance and Operate contracts. Many Waste Disposal Authorities in two tier English arrangements (County Councils) seek 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.

Contractual and Financing Issues

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:

Defra Procurement Toolkit[5];

For Works Contracts: the Institution of Civil Engineers 'New Engineering Contract'[6];

For large scale Waste Services Contracts through PFI and following the Negotiated Procedures the 4ps 'Waste Procurement Pack'[7]; and

Local Government PFI project support guide[8].

---

[5] http://lasupport.defra.gov.uk/Default.aspx?Menu=Menu&Module=Article&ArticleID=102

[6] available at www.ice.org.uk

[7] available at www.4ps.gov.uk

[8] www.local.odpm.gov.uk/pfi/grantcond.pdf

This section contains information on the planning and regulatory issues associated with ATT facilities based on case studies of existing facilities and information on planning from the Office of the Deputy Prime Minister research report[9].

Planning

When considering the planning implications for an ATT facility the following issues should be considered:

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

Some of these issues are discussed elsewhere in this guide but a brief overview of each is provided here.

Plant Siting

ATT can take place in many different buildings at a variety of locations but the following considerations should be made:

- Preference should be given to sites for business use or traditional commercial/industrial urban areas. Existing waste management facility sites may also be considered;
- The site chosen should be close to the primary road network or rail head connection, especially if it is to be a large scale/centralised facility. The site should be appropriate for the movement of HGV traffic without major restriction. Smaller ATT facilities may not require such infrastructure to support them.
- Under current rules, premiums are only awarded for electricity generated from renewable sources in plants such as this. As fuel prices may rise over time and if supply security is questioned, considerations must always be given to utilising not only the electricity from the plant but also the waste heat. As a result specific plant should look to be sited close to where its electrical and thermal outputs can be used. In the UK this is likely to reduce the size of such plant.

Traffic

ATT 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.

Air Emissions/Health Effects

Flue Gases

In terms of complying with the Waste Incineration Directive (WID) the major emission from a plant with energy recovery is the release of flue gases from the combustion of the syngas (and in some instances also the residual solid, if it has high carbon content). The clean-up required for the flue gases is dependent on the process from which they have been generated. One of the main benefits claimed by manufacturers for pyrolysis and gasification plant is that emissions of pollutants are lower than those from conventional mass burn incineration and that plant are designed to comply with the emission limits set out in the Directive.

Entrained (fine) particles in the syngas can either be removed before or after combustion depending on the treatment process and combustion technology employed.

A further solid residue produced is from abatement plant used to clean-up the flue gases from the combustion process. Both of these solid streams are hazardous in nature and must be disposed of appropriately. Often they are combined as they are removed during the same stage of the flue gas clean-up.

[9] http://www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_030747.pdf

In addition to the conventional approach of flue gas clean-up, an alternative approach could be adopted in which the syngas is cleaned prior to use as a fuel to a level where the resulting flue gases could be released to atmosphere without further cleaning. However, the cleaning of syngas to a standard where the requirements of the WID no longer apply has not yet been demonstrated.

The Defra study on Health & Environmental effects of Waste Management processes (see Further Reading) found no evidence of health effects linked to ATT facilities, however due to the emergent nature of these technologies, the available data was only of a moderate quality. More detail on this issue is included in the Defra report[10].

Dust/Odour

Any waste management operations can give rise to dust and odours. These can be minimised by good building design, performing all operations under controlled conditions indoors, good working practices and effective management undertaken for dust suppression from vehicle movements. Many ATT processes are designed to operate under negative pressure within buildings to minimise dust and odour problems.

Flies, Vermin and Birds

ATT processing is unlikely to attract vermin and birds due to majority of waste throughput and operations being completely enclosed in buildings. However, during hot weather it is possible that flies could accumulate, especially if they have been brought in during delivery of the waste. Effective housekeeping and on site management of tipping and storage areas is essential to minimise the risk from vermin and other pests. In some operations waste heat from the process may be 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.

Noise

Noise is an issue that will be controlled under the waste licensing regulations. The main contributors to noise associated with ATT 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.

Litter

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

Water Resources

Water will be used but this 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.

Visual Intrusion

Virtual image of proposed ATT facility

Construction of any building will have an effect on the visual landscape of an area. Visual intrusion issues should be dealt with on a site specific basis and the following items should be considered:

- Direct effect on landscape by removal of items such as trees or undertaking major earthworks;
- Site setting; is the site close to listed buildings, conservation areas or sensitive viewpoints;

[10] http://www.defra.gov.uk/environment/waste/research/health/index.htm

- 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;
- Use of screening features (trees, hedges, banks etc); and
- The number of vehicles accessing the site and their frequency.

Many of these facilities are housed in 'warehouse' type clad steel buildings, however use of good design techniques can help minimise visual intrusion.

Size and Landtake

Table 4 shows the land area required for the building footprint and also for the entire site (including supporting site infrastructure) for examples of Advanced Thermal Treatment facilities.

Table 4 : Landtake

TT Facility	Size, tonnes per annum	Buildings Area m^2	Total Landtake Ha	Indicative Stack Height
Mass Burn*	90,000	5,850	1.7	65m
Mass Burn*	250,000	6,600	4	70m
Pyrolysis†	60,000	-	0.98	-
Pyrolysis†	12,500	200	+ access	
Pyrolysis†	35,000	28,000 - 32,000	4	-
'General ATT'*	50,000	3,600	1-2	30 - 70m

Source:

* Planning for Waste Management Facilities - A Research Study, ODPM 2004

† Waste Technology Data Centre

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

Public Concern

The Social and Perception Issues section 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 perceived issue.

Environmental Impact Assessment

It is likely that an Environmental Impact Assessment (EIA) will be required for an ATT facility as part of the planning process.

Whether a development requires a statutory EIA is defined under the Environmental Impact Assessment (England and Wales) Regulations 1999. Further guidance is available in the DETR circular 02/99 on Environmental Impact Assessment.

For more information on Planning issues associated with waste management options see Planning for Waste Management Facilities - A Research Study. ODPM, 2004 see footnote 9.

Licensing/Permitting

Currently, the interpretation of all Advanced Thermal Treatment operations is that they require a Pollution Prevention & Control (PPC) permit. It would be prudent to assume that any facilities will be covered by the PPC Regulations.

For more information on licensing & permitting see the Environment Agency web site[11].

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

Social and Perception Issues

This section contains a discussion of the social and environmental considerations of ATT facilities.

Social Considerations

Any new facility is likely to impact on local residents and may result in both positive and negative impacts. Potential impacts on local amenity (odour, noise, dust, landscape) are important considerations when siting any waste management facility. These issues are examined in more detail in the Planning & Permitting chapter of this Brief. Transport impacts associated with the delivery of waste and onward transport of process outputs may lead to impacts on the local road network. The Planning and Permitting chapter of this Brief provides an estimate of potential vehicle movements.

An ATT facility may also provide positive social impacts in the form of employment and educational opportunities. Typical employment for a ATT plant of 50,000tpa capacity would be 2-6 workers per shift. The plant would operate on a 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.

Public Perception

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

At present there is a relatively low level of understanding of the concept of ATT by the public. There are no full scale commercial ATT operations in the UK processing MSW. In public consultations these technologies score inconsistently when explained in detail as a residual waste treatment technology. There is a general distrust of thermal systems in the UK, however some ATT providers accentuate the differences of their systems from incineration as a key part of the promotion of their technology.

Overseas development of advanced thermal treatment again shows inconsistencies in public opinion. In Australia developments of ATT plant received similar perceptions to that of incineration, partly due to campaigns from national environmental groups claiming parallels between the technologies. The national environment campaign organisations in the UK are divided on this issue. The UK public opinion has yet to be tested on ATT proposals.

Overall, experience in developing waste management strategies has highlighted the importance of proactive communication with the public over waste management options. The use of realistic and appropriate models, virtual 'walk - throughs' / artists impressions should be used to accurately inform the public. Good practice in terms of public consultation and engagement is an important aspect in gaining acceptance for planning and developing waste management infrastructure. Defra are funding the development of small to medium scale demonstration plant in England for local authorities to visit and for Defra to publish data on performance. For more information contact the New Technologies Supporter helpline on tel. 0870 2409894 Wastetech@enviros.com

Costs of Advanced Thermal Treatment

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

Typically around 40% of the capital costs for operating a plant will be to cover capital depreciation. As a result these need to be viewed as large capital investments (which will require replacement components during its lifetime) with a lifespan of not less than 10 or more usually 20 years.

Plants of this type have been applied to chemical and process industries; these have all been large scale, capital intensive applications.

It is vital in any negotiation, that a true appreciation of the cost of essential repairs and refurbishment be taken into account.

For cost information on examples of different processes see Defra's Waste Technology Data Centre.

www.environment-agency.gov.uk/wtd

Contribution to National Targets

Recycling

Recyclate derived from an ATT plant processing household waste qualifies for BVPI 82a (Recycling) for any materials recovered prior to the thermal treatment reactor. Any materials recovered after the thermal treatment (e.g. metals from the ash), do not count towards BVPI 82a. Equally any char or 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 if additional materials are extracted from the front end of the process for recycling, they may experience market limitations due to being derived from a mixed MSW source.

Further information about BVPIs can be obtained from the Defra website and associated links[12].

Recovery

ATT technologies will contribute towards recovery targets on the tonnage of materials entering the thermal treatment process as all processes are designed to recovery energy. For more information see the Defra website and associated links[14] and the guidance on BVPI 82c.

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. ATT 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 relating to LATS can be obtained from the New Technologies Supporter Helpline and Defra's LATS information webpage[13].

Renewable Energy

The Renewable Obligation (RO) was introduced in 2002. Its function is to promote the development of electricity generated from renewable sources of energy. The obligation requires an increasing percentage of the electricity supplied to be from renewable sources for each year through to 2010. The target for 2010 is set at 10%. The RO consultation for 2005 proposed that the targets for the obligation are extended, with a target of 15% proposed for 2015. The obligation requires suppliers to surrender certificates (known as Renewable Obligation Certificates - ROCs) to demonstrate that they have supplied the required amount of renewable electricity. If the supplier cannot surrender the required amount of certificates it can buy out the shortfall at a price of 3 p/kWhe. This buy out means that ROCs have a value and therefore generators of renewable electricity (as defined in the obligation) can sell the electricity they generate and the ROCs, which means they receive a premium for the power they produce. The value of a ROC is dependent on availability. If the suppliers fail to meet their target set in the RO then certificates will be worth more than the buy out price of 3 p/kWhe. However, if the available quantity of renewable energy exceeds the target then the value of ROCs would drop.

To encourage the development of Advanced Thermal Treatment technologies, the RO was amended in 2004. The amendment stated:

> "A generating station shall be an excluded generating station in any month during which it is fuelled with waste or partly by waste unless - (a) the only waste by which it is fuelled is biomass; or (b) all of the waste by which it is fuelled in that month which is not biomass has first been manufactured into a fuel which is in either a gaseous or liquid form (or both) by means of a plant and equipment using advanced conversion technology only."

This means that renewable fraction of the electricity generated from the Advanced Thermal Treatment of MSW is eligible for ROCs. [The renewable fraction is the gross energy content of the waste that is considered to be renewable (biomass)] This would provide an 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 renewable obligation is currently out to consultation for a proposed revised system.

---

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

Further Reading and Sources of Information

Up-to-date information regarding RDF and ROCs can be obtained from the DTI website or the New Technologies Supporter Helpline
tel. 0870 2409894
Wastetech@enviros.com

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

New Technologies Supporter Helpline
Tel. 0870 240 9894
E: Wastetech@enviros.com

Defra New Technologies website,
http://www.defra.gov.uk/environment/waste/wip/newtech/index.htm

The Viability of Advanced Thermal Treatment of MSW in the UK, Fichtner Consulting Engineers Ltd, ESTET, 2004.

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. Enviros Consulting Ltd. ODPM, 2004.
http://www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_030747.pdf

Procurement Toolkit
http://lasupport.defra.gov.uk/Default.aspx?Menu=Menu&Module=Article&ArticleID=102

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

For large scale Waste Services Contracts through PFI AND following the Negotiated Procedures the 4ps 'Waste Procurement Pack' www.4ps.gov.uk

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.
Biodegradable	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.
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.
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.
Global Warming	The progressive gradual rise of the earth's surface temperature thought to be caused by the greenhouse effect and responsible for changes in global climate patterns. An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases form man-made sources.
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/Materials 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.

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, for which each supplier of electricity 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 that 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.

www.defra.gov.uk

defra

Waste Implementation Programme
New Technologies