

ENERGY

ENERGY FROM WASTE A WASTED OPPORTUNITY?

Institution of
**MECHANICAL
ENGINEERS**

Improving the world through engineering



This report focuses on the benefits of the UK creating an Energy-from-Waste network which would help power the nation and reduce the need for landfill. This report has been produced in the context of the Institution's strategic themes of Energy, Environment, Education and Transport and its vision of 'Improving the world through engineering'.

ENERGY

ENVIRONMENT

EDUCATION

TRANSPORT

CONTENTS

02	A WASTED OPPORTUNITY EXECUTIVE SUMMARY
05	WHAT IS AN ENERGY-FROM-WASTE PLANT?
08	WHAT ARE THE PROBLEMS WITH WASTE IN THE UK?
12	RESOURCING OUR WASTE
14	DOUBLE STANDARDS — THE PROXIMITY PRINCIPLE
16	THE DANISH CONNECTION
18	IS THIS A WASTED OPPORTUNITY?
20	REFERENCES

WHAT ARE THE ISSUES?

With the UK producing over 300 million tonnes of waste per year, enough to fill the Albert Hall every two hours, and our love affair with landfills soon coming to an end, we could shortly be up to our necks in waste with, apparently, few options for tackling the problem.

The mantra we generally hear is 'recycle it'. But is recycling always the best solution? Not if there's no demand for the recycled materials. Not if more energy is consumed and more greenhouse gases are emitted in the recycling process than would be used to manufacture a new product. Not if we don't actually recycle but instead just sort the waste into piles of different materials and then ship those piles overseas with no control over what happens to them after that.

Secondly, as the public begins to feel the impact of global energy price rises, the UK needs to quickly find sustainable and secure sources of energy, using reliable, well-proven technologies. And to have any chance of minimising the impacts of global climate change, countries such as the UK must find ways to meet their material and energy needs whilst rapidly and significantly cutting their greenhouse gas emissions.

Is there a realistic solution to both these issues? Yes. This is a route that the UK could adopt which would change our perceptions of waste and its disposal, contribute to our battle against climate change and help meet our needs for affordability and security of energy supplies.

In recent years the Institution of Mechanical Engineers has been advocating that waste should not be regarded as a problem to be 'dealt with' but as a valuable resource which could help us meet our national and regional environmental targets and commitments.

This is by developing a network of Energy from Waste plants (EfW).

LETTING A RESOURCE GO UP IN SMOKE!

In the UK, we traditionally adopted two simple ways of dealing with waste: bury it (known as landfilling), or burn it and bury what was left (known as incineration).

However, as the world becomes more environmentally aware, there is a growing recognition that harmful emissions from both these methods are unacceptable and that alternatives need to be found.

Of course, different waste streams should be regarded as resources in different ways, e.g. metals should be collected, sorted into different types and re-melted. However, for many other types of waste, recovering its value to provide electricity, heat and/or transport fuels is an easy, valuable and more environmentally sound solution than recycling or landfilling. Modern EfW plants meet very strict environmental standards and perceptions of them as 'dirty' need to be robustly and forcefully challenged.

It is important to note that an EfW plant should not be seen as a waste treatment plant but more accurately as a power station or even a Combined Heat and Power (CHP) station. A thermal EfW plant, in particular, 'treats' waste in the same way that a coal-fired power station 'treats' coal. Any other benefit, such as volumetric reduction, is a useful by-product but is not the primary purpose of an EfW plant.

Unfortunately, most legislation over recent years has erroneously and dogmatically focused on EfW as waste treatment rather than as energy production, and has attempted to deal with an EfW plant as if it were an incinerator, rather than a power station. The approach is very different in most other parts of Europe, where recycling and EfW are both used to their optimum potential, and, as a result, landfilling is successfully minimised.

EfW, in its various formats, is the only 'renewable' (most suitable 'waste' is bio-waste) technology which can realistically meet the EU and UK 2020 commitments for 'heat' and 'transport' sector requirements, whilst at the same time also providing significant quantities of electric power.

For larger waste streams, combustion technology inherently produces both heat and power, in the ratio of two to three times as much heat energy as electrical, although in the UK we have traditionally wasted the heat by exhausting it to atmosphere, even more ridiculous when we have over one million people classed as being in fuel poverty!

It is extremely improbable that the UK's legally binding renewable energy commitments can be reached unless EfW plants cease to be regarded as a less-desirable form of waste treatment process and become regarded as the best-proven, safe, clean energy recovery solution available to us.

WHAT NEEDS TO HAPPEN?

The Institution of Mechanical Engineers therefore recommends the following:

- 1.** The Government should review its energy strategy and make EfW a key component in energy production, with the added benefit of avoiding waste to landfill.
- 2.** The Government should promote and encourage investment in district and community heating projects with local 'waste' being used as the fuel resource. Appropriate targeting of such schemes could help to eliminate energy poverty in the UK within a generation.
- 3.** The Government should redefine waste as an energy resource, allowing the new Department for Energy and Climate Change to focus on its optimal use.
- 4.** The Government should abandon its focus on recycling as the only way to rid us of landfills, as this is quite unachievable and is clearly deceiving the public about what is really happening to their waste.
- 5.** Recycling should only be for waste products which cannot be more sustainably converted into electricity, heat and/or transport fuels.

Spittelau EfW plant, Vienna.

Using innovative design has made this plant a tourist attraction for the city while heating 190,000 homes, generating 36,000 MWh of electricity and removing 263,200m³ of waste.



WHAT IS AN ENERGY-FROM-WASTE PLANT?

An Energy from Waste (EfW) plant works by taking the waste and converting its potential energy into any type of usable energy – the three main forms being heating, electricity and transport fuels – just as coal, oil and gas are used as fuels in fossil-fired power stations.

EfW can be used with many different types of waste from domestic, commercial, industrial, construction and demolition, to sewage and agricultural etc. The only criterion is that the waste fraction is combustible and/or biodegradable.

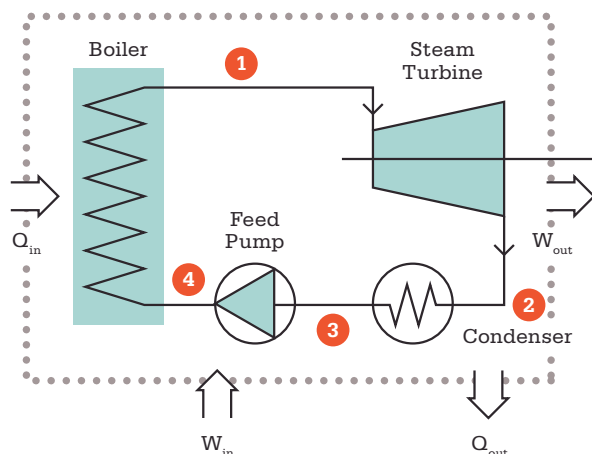
It is important to note that an EfW plant is not the same as an 'incinerator' and it is highly misleading to describe it as such. An incinerator is purpose-built to reduce the volume of waste by burning (incinerating) it to produce an ash which is disposed of elsewhere, e.g. to landfill. An EfW plant, by contrast, is purpose built to provide usable energy and can be designed to have little or no output to landfill.

Most EfW plants should correctly be described as **combustion** systems which are 'the process of burning' or 'any process in which a substance reacts to produce a significant rise in temperature and the emission of light' or 'a process in which a compound reacts slowly with oxygen' with the creation of energy and heat which can be used.

Most people in the UK, and seemingly the Government, do not know the difference between 'incineration' and 'combustion'. The term 'incineration' stems from the outdated method of burning Municipal Solid Waste (MSW) in order to destroy it. This thinking, in turn, derives from seeing waste as a 'problem' rather than as a 'resource'; there is a particular issue here, in that the UK Government is itself very unclear on this subject! Defra, for example, constantly refers to EfW plants as 'incinerators' and despite public consultation on this issue appears to have ignored the feedback!

Ironically, the European Directive governing EfW plants is known as the Waste Incineration Directive (WID) whereas, for large utility power stations, the relevant directive is known as the Large Combustion Plant Directive. Since the latter is describing a virtually identical process to EfW, it is not at all clear why the Government has decided that one is 'combustion' and the other is 'incineration'. If we were to describe Drax (a coal-fired power station in Yorkshire), for instance, as a plant whose primary purpose is to reduce the volume of coal, render it inert and from which power is 'recovered', we would rightly be treated with derision; logically, this should be the same response when people describe EfW plants in the same way.

Figure 1 The Rankine Cycle



EFW PROCESSES

There are four main processes which are used in EfW plants, three are thermal (combustion, gasification and pyrolysis) and one is biological (anaerobic digestion). For reasons which are not at all obvious, as all four processes have been in widespread use for many decades, the Government has decided that 'gasification', 'pyrolysis' and 'digestion' are Advanced Conversion Technologies (ACTs), while 'combustion' is not.

Combustion

This is the most common and well-proven thermal process using a wide variety of fuels. The combustion process is that used in all the large coal-fired power stations in the UK, for example, and follows a process known as the Rankine Cycle.

The Rankine Cycle is a simple thermodynamic cycle in which a steam turbine or engine operates. In the conventional steam Rankine Cycle, there are four major components, the steam turbine (or engine), the condenser, the boiler feedwater pump and the boiler itself. **Figure 1** shows these four components within a system boundary to demonstrate the main inputs and outputs. Heat from burning the fuel (Q_{in}) is applied to the system via the boiler and is dissipated (Q_{out}) from the system via the condenser cooling medium. Similarly work (W_{in}) is applied to the system to drive the boiler feedwater pump (usually in the form of electricity) and work (W_{out}) is exported from the system via the turbine drive shaft.

The Rankine Cycle inherently produces both electric (or mechanical) power and heat. The heat energy produced is not a by-product, as with some other processes, but is the basic principle on which the system works. It is therefore, inherently, a CHP plant. The primary issue in the UK is that we have become accustomed to using only the electrical output of the plant (the W_{out} in the diagram) and have wasted the enormous amount of heat energy (Q_{out}), which can be two to four times as large as the electrical output of the plant.

Gasification

This is defined as a thermal reaction with insufficient oxygen present for reaction of all hydrocarbons (compounds of carbon, hydrogen and oxygen molecules) to carbon dioxide (CO_2) and water (H_2O). Gasification is where oxygen in the form of air, steam or pure oxygen is reacted at high temperature with the available carbon in the waste to produce a gas (e.g. methane, CH_4), ash or slag and a tar product. Although the gasification method is very recent in its application to biomass and waste materials, the underlying technology, the gasification of coal, is now extremely well proven. The major benefit of gasification of bio-wastes is that the product gas can be used directly, after significant cleaning, to fuel a gas turbine generator which itself will form part of a CHP or Combined-Cycle Gas Turbine system, thus theoretically improving the overall thermal efficiency of the plant. The main disadvantage is that there are many more items of large equipment and the capital investment is correspondingly higher, so the pay-back period will have to be carefully defined.

Pyrolysis

This is also a thermal process and involves the thermal degradation of organic waste in the absence of free oxygen to produce a carbonaceous char, oils and combustible gases.

Although pyrolysis is an age-old technology, its application to biomass and waste materials is a relatively recent development. An alternative term for pyrolysis is thermolysis, which is technically more accurate for biomass energy processes because these systems are usually starved-air rather than the total absence of oxygen. Although all the products of pyrolysis may be useful, the main fuel for power generation is the pyrolysis oil. Depending on the process, this oil may be used as liquid fuel for burning in a boiler or as a substitute for diesel fuel in reciprocating engines, although this normally requires further processing.

Anaerobic Digestion (AD)

This is a biological process which is a method most commonly used with liquid and semi-liquid slurries such as animal waste. It is also used for obtaining gas from human sewage, but is now being applied to a limited degree to certain other wastes and biomass streams. AD utilises the same biological processes that occur in a landfill site, but under controlled conditions in a digester system. The four-stage process of hydrolysis, acidification, acetogenesis and methanogenesis takes place in the digester tank, which is a warmed, sealed, airless container where bacteria ferment organic material in oxygen-free conditions to produce biogas. The amount of biogas produced is limited by the size of the digester tank, so is largely used as a fuel which may be burned in a conventional gas boiler to heat nearby buildings or in a reciprocating engine which is used to generate electricity.

The main advantage of AD is that it deals well with 'wet' waste, which is a real problem for all other forms. It is also ideal for small-scale operations, such as farms, where enough energy (electricity and heat) can be produced to run the farm (including fuelling some of the vehicles) from what is produced on the farm. Its drawbacks are that it takes up a relatively large amount of space and it is often difficult to avoid odours, both of which make it less suitable for urban installations. Furthermore, it is relatively inefficient (i.e. amount of useful energy recovered) when compared on a like-for-like basis with other forms of EfW, because not all of the organic matter is converted; figures as low as 20-25% of the efficiency of a combustion EfW plant have been heard. Furthermore, most AD systems tend to be 'batch' rather than 'continuous' processes, which means that parallel systems are required if a continuous output is needed.

THE CURRENT SITUATION

Combustion is, by far, the most commonly used technology, both in the UK and other European countries, although the incidence of plants in many other countries is very much greater than it is in the UK, where the public distrust of these plants (e.g. by erroneously calling them 'incinerators') has been encouraged by several NGOs and other pressure groups over the years.

The second is AD, mainly because it is seen by Government, NGOs and the like as a 'safer' and more 'environmentally friendly' option. There is little substance to these claims.

Neither pyrolysis nor gasification has yet achieved any great market penetration, mainly due to enormous teething problems with both of these processes where they have been tried, mainly in other countries.

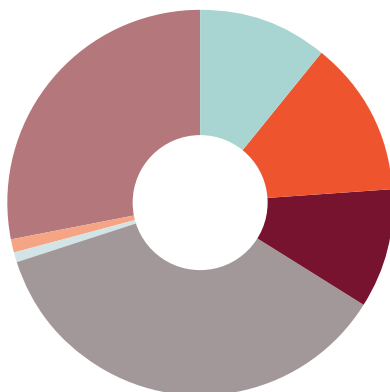
By 2005 there were 19 EfW plants operating in the UK fuelled by MSW or Refuse-Derived Fuel; four more were under construction, three more had planning consent and a further four had applied for planning consent. The situation has changed substantially over the intervening years and some of the plants planned at that time are now in operation.

However, because of the lack of real operating experience with other processes, almost all the current EfW plants in the UK are of the combustion type. This is largely because gasification and pyrolysis processes are still not adequately proven for use with waste and AD, while growing in popularity, is better suited to smaller rural installations such as farms.

Accurate statistics for total waste are notoriously hard to come by in the UK. This is largely because of what is defined as waste and the legislative pre-occupation with Municipal Solid Waste (MSW), to the virtual exclusion of all other types. In 2005, it was estimated that the UK produced 307 million tonnes of waste (per year)¹ or 'enough to fill the Albert Hall every two hours'². This is quite simply not sustainable.

Of that, Defra also estimated that 46.4 million tonnes of 'household and similar waste' were produced in the UK with 60% of this landfilled, 34% 'recycled' and 6% 'incinerated'. According to the official statistics, none of this resource was used as fuel in EfW plants.³ However in reality, the 6% classified as 'incinerated' was actually combusted in EfW plants.

Where our waste comes from:



- Household waste (11%)
- Commercial waste (13%)
- Industrial (10%)
- Construction and demolition (36%)
- Agriculture (1%)
- Sewage (1%)
- Mining and quarrying (28%)

TYPES OF WASTE

The following shows the approximate percentages of waste arising in the UK.

Household waste [11%], i.e., the waste we produce in our homes; this will be a varying mixture of, for example, food waste that is biodegradable, plastics which are not biodegradable but combustible, metals which are neither biodegradable nor combustible but are recyclable, glass which is neither biodegradable nor combustible and is difficult to recycle, paper which is biodegradable, combustible and recyclable, etc. This simple description exposes the folly of assuming that all domestic waste is, or can be, 'recyclable' in the narrow definition that this word has been given in the UK.

Commercial waste [13%], which is predominantly office waste emanating from the service sector, is similar in consistency to domestic waste and is increasingly being regarded with domestic waste as MSW.

Industrial waste [10%] contains all the elements of commercial waste but with the additional by-products of liquid effluents, oils, which are increasingly being regarded as 'hazardous' and which have to be dealt with separately.

Construction and demolition (C&D) waste [36%]; this generally differs considerably from the foregoing waste streams in that it contains a high proportion of minerals which are not biodegradable or combustible and which are often not worth recycling. There is, however, normally a percentage of wood waste which is, of course, readily combustible or biodegradable over time. The major problem with the wood element of C&D waste is that it is almost invariably treated in some way, chemically or painted or otherwise contaminated, which may be classified as hazardous under present legislation and may have to be dealt with in specially designated facilities.

RESOURCING OUR WASTE

Agricultural waste [$<1\%$] varies hugely depending on the type of farming in a particular area: arable farming produces a greatly different waste stream from livestock farming, for example. Agricultural waste is a catch-all phrase for waste streams as different as cattle dung, poultry litter, used fencing, asbestos, plastic wrapping, all of which have to be dealt with in very different ways. A further problem is that much agricultural waste does not enter the statistics, as farmers deal with it themselves as they have always done.

Sewage waste [$<1\%$], although usually dealt with by completely separate legislation, included under the general heading of 'waste'; 'sewage' refers solely to the biological waste produced by human beings. However, unlike the dung of most animals, because of our modern diets, human sewage contains trace elements which are deemed to be undesirable (even after suitable treatment) for spreading on arable land.

Mining & quarrying (M&Q) waste [28%] is probably the most forgotten single waste stream in the UK but is the second largest. The main problem with M&Q waste is that it is nearly all mineral waste, which is neither biodegradable nor combustible and is difficult to recycle. It lends itself ideally to 're-use', the second priority in the hierarchy, but this usually requires energy-intensive processes which render it commercially unattractive and may well have an unacceptable carbon footprint, since the waste is largely inert material.

COVERING UP THE PROBLEM OF WASTE

The trouble is waste needs to be dealt with. In the past the UK has adopted a landfill policy – bury all waste. However, today the UK is reluctantly phasing out landfill sites, partly because it is running out of suitable locations for new landfills and partly because of the European Landfill Directive⁴(1999) which was passed into law in England and Wales in 2002⁵ and Scotland in 2003⁶ and will require the organic fraction of landfilled waste to be reduced by:

- 25% by 2010,
 - 50% by 2013 and
 - 65% by 2020
- (all below 1995 levels)

Although the above relates only to the organic fraction of waste streams, there is a growing societal movement to eventually dispense with landfill completely as a means of waste disposal. However, unlike most other European governments, both the UK and Scottish Governments have decided that the main alternative to landfill will be 'recycling' and that 'recovery' (by which they mean EfW) is only slightly preferable to landfill. We have already exposed the fallacy of this argument and believe that the only positive way to avoid landfilling in the future is through a pragmatic combination of recycling and EfW.

Photograph provided courtesy of SITA, Isle of Man: This EfW facility provides 10% of the Island's electricity.



“ ”

**GOVERNMENT SHOULD REVIEW
ITS ENERGY STRATEGY AND
MAKE EFW A KEY COMPONENT
IN ENERGY PRODUCTION,
WITH THE ADDED BENEFIT OF
AVOIDING WASTE TO LANDFILL.**



The type of waste taken by an EfW plant is dependent on which of the four main technologies has been chosen. In fact, the type of waste stream may itself determine which technology is chosen. For example, 'wet' biowaste can really be dealt with only in an AD system which is most effective in dealing with slurries rather than solids. Examples of wastes which are best dealt with by AD are animal waste, e.g., cattle dung, food waste, e.g., from kitchen and catering, although increasingly green waste and vegetable matter are proving to be good feedstock for AD systems.

Thermal processes, on the other hand, are more efficient when the 'dryness fraction' is high, i.e., moisture content is low. The thermal processes are ideally suited to solid wastes, although certain liquids and gases can also be used if they are suitable for combustion. Wood waste from construction and demolition sources, for example, is usually very dry and makes an ideal feedstock for thermal processes. Green wood, such as is derived from thinning and trimmings in forestry, will have to be dried for a certain period, before entering the thermal process.

Non-combustibles, such as metals, glass and other inert materials, are unsuitable for EfW plants and are normally recycled by other means. Most plastics cannot be dealt with by biological process, but usually have a very high energy content which makes them very suitable for the combustion process. It should be noted, however, that the vast majority of plastics will have been manufactured from fossil fuels and this portion of any waste stream cannot therefore be classed as 'renewable'.

The other main output of a conventional, combustion EfW plant is ash. This is normally of two different types: a relatively small quantity of 'fly ash' which is legally considered to be hazardous and therefore is disposed of in a hazardous landfill site. The much larger quantity of bottom ash is inert and can be used as roadfill or aggregate for concrete manufacture – although some still goes to landfill.

SUGAR LUMPS IN LOCH NESS— THE EMISSIONS MYTH.

It is in this area that the greatest myths have arisen about EfW plants. It is also where the malicious confusion of EfW plants with incinerators has been most misleading to both the public and Government.

The emissions from the EfW plant itself will vary depending on a) the technology used and b) the 'waste' feedstock. Since most of the public concern is related to combustion EfW using MSW as a fuel, we shall concentrate on this area.

Most of the world's thermal power stations use the combustion process, and this process has been refined over many years to ensure as complete combustion of the fuel as possible. As a general rule, the more complete the combustion, the cleaner will be the resulting emissions. The resultant emissions from the Rankine Cycle process will range from most dirty in the case of coal as fuel, to least dirty in the case of natural gas as fuel, with MSW as fuel lying somewhere between the two.

Logically, the dirtier the emissions from the power station are, the more they must be cleaned up in an emissions control plant before they are finally released into the atmosphere. So even a dirty combustion process need not necessarily lead to harmful emissions to atmosphere.



**THE DIOXIN EMISSIONS
LIMIT FOR AN EFW PLANT
IS AN EQUIVALENT
CONCENTRATION TO ONE
THIRD OF A SUGAR LUMP
DISSOLVED IN LOCH NESS.**

The emissions control plant (which is not an integral part of the Rankine Cycle process) is nowadays designed in a series of clean-up stages which may include cyclonic separators, bag filters and/or active carbon filters⁷. Progressively tightening legislation over several decades has led to any power plant nowadays being considerably cleaner in its emissions than has ever previously been the case.

Modern emissions control systems are capable of reducing particulate matter in the power station emissions to incredibly low proportions; indeed, many modern power stations actually clean the ambient air as it passes through the power station!

Because of public concerns about the emissions from EfW plants, a European Directive on the Incineration of Waste⁸ was developed in 2000, which is now almost always referred to as the Waste Incineration Directive (WID), passed into law in England and Wales in 2002⁹ and in Scotland the same year¹⁰.

Applying WID to a combustion EfW plant is relatively straightforward in technical terms, but has required substantial redesign of the combustion process technology and is therefore very costly. The net result, however, is that the emission concentrations from a combustion EfW plant are required to be ten times lower than from an equivalent large, coal-fired combustion plant.

Former incinerators acquired something of a reputation for producing certain toxins, mainly dioxins and furans. Nevertheless, bad though they were in this respect, incinerators were never the sole, or even major, cause of the emission of such toxins. Other sources, such as barbecues, fireworks, etc still produce as many dioxins but there are more emissions emanating, for example, from our coal-fired power stations.

Specifically regarding dioxins, Enviros and the University of Birmingham concluded: "Dioxins and furans are emitted approximately equally from landfill and incineration."¹¹ Defra concluded: "Dioxin emissions from modern energy from waste plants – all of which must now meet the very stringent requirements of the EU Waste Incineration Directive – are very small compared with other common environmental sources such as building and forest fires, and even fireworks. The emission limits under this directive are lower than those for non-waste energy generation sources."¹²

The dioxin emission limit value required by WID from an EfW plant is a concentration in the chimney of 0.1 ng/m³ (one billionth of a gram per cubic metre at ambient temperature and pressure). This is an equivalent concentration to one third of a sugar lump dissolved evenly in Loch Ness.

However, unlike dissolving sugar in Loch Ness where the concentration would increase as more sugar is added, emissions from the EfW plant are diluted an infinite amount as they mix with the surrounding air.¹³

DOUBLE STANDARDS — THE PROXIMITY PRINCIPLE

14_15

EfW plants can be designed for a very wide range of sizes and can be suited to either local or regional energy production. However, documents such as the Defra Waste Strategy 2000 insisted on the 'proximity principle' regarding the transport of waste, so the official trend is towards local plants rather than regional or centralised plants.

The 'proximity principle' does indeed make sense if the heat energy from the EfW can be utilised in a district or community heating scheme, 'heat' being more difficult to transport over long distances. However, if the UK continues its present policy of using only the electrical output of an EfW plant and simply wasting the heat energy, then there are economies of scale to be gained from larger, more centralised, plants¹⁴.

Furthermore, the 'proximity principle' is rather a double standard in the way it is applied in the UK. It is very rigorously applied to EfW plants and 'truck movements' are frequently cited to refuse planning permission for larger EfW plants. On the other hand, the 'proximity principle' is not applied at all to recycling plants.

Once 'recyclables' are delivered to the Material Recycling Facility – which is normally a separating and sorting centre, not a recycling plant – they are officially declared as 'recycled' (i.e. they are counted towards the local or national recycling targets because those statistics, as explained earlier, treat 'sent for recycling' to be the same as 'recycled'). Because actual recycling plants in the UK are still few and far between, many recyclables are actually transported for considerable distances within the UK. However, there is a much more serious issue in that huge quantities of some major recyclables (particularly paper and plastics), which have already been classified as 'recycled' and counted towards UK and local targets, are being shipped to countries such as China, where we do not know whether they are actually recycled or merely used as cheap fuel.

GOING TO WAR!

There are several modern EfW technologies which have now moved on from the conventional EfW described above to become 'all-in-one' facilities for energy production and recycling. These are better known as Waste-as-Resource (WaR) facilities.

An integral part of a WaR facility is that it recovers as much energy as possible from the thermal process, which is usually a combination of combustion and gasification. Not only is a higher proportion of energy normally produced as electricity, but much of the thermal energy (waste heat) is recovered and used in district heating schemes and/or in the various industrial processes in the plant.

A further objective in WaR facilities is to significantly reduce or eliminate sending ash to landfill. A WaR plant may incorporate a plasma vitrification system (for recycling wasted glass) which can take the 'fly ash' and safely encapsulate it in the glass product. A WaR plant also has an integrated concrete plant where bottom ash is used as aggregate in a variety of building and construction products.

The input and output data for a proposed WaR facility in Peterborough, UK is provided below:

Typical Fuel Mix for proposed Peterborough WaR plant (1 million t/y):

• Industrial/Commercial Waste	410,000 t/y
• Municipal Solid Waste (MSW)	300,000 t/y
• Sewage Sludge	90,000 t/y
• Tyres	30,000 t/y
• Oil/Thinners (after recycling)	20,000 t/y
• Locally-grown Biomass	150,000 t/y

Normal WaR Plant Annual Outputs:

- 126 MW Electric Power NETT (>1.0 TWh)
- Up to 58,000 m³ Concrete
- 145,000 tonnes Aggregates – block products
- 2,500 tonnes Non-ferrous metal ingots
- 30,000 tonnes Iron & Steel
- 50,000 tonnes Glass Products (tiles, filtration, enamel etc)
- 12,000 tonnes Hydrochloric Acid
- Up to 4,000 tonnes Pure Sulphur
- Up to 2 tonnes Pure Mercury
- 725,000 MWh Renewable Obligation Credits
- 1,300,000 tonnes Carbon Credits
- ZERO output to landfill

At the public hearing in January 2006, following five years of hard work and significant investment by the developer, this highly innovative resource recovery plant was refused its planning application.¹⁵

Many of the most developed countries in Europe recognised the problems associated with landfill long before the UK did, and have been developing alternative processes for dealing with waste for several decades. The two main methods of landfill reduction are recycling and EfW.

In most European countries, it is normal to build EfW plants as part of the communities that they serve, so the waste from the community is used as fuel in the EfW plant, which then supplies electricity and heat back to the community. This is a very much healthier approach than that traditionally taken in the UK, where EfW plants are often hidden away and separated from their natural communities.

CASE STUDY: DENMARK

Although most European nations do very much more EfW than the UK does, the most notable example of the intelligent use of EfW in Europe is Denmark.

Because most of Denmark is fairly densely populated and Danish people are more environmentally aware, landfill has not been considered an acceptable way of dealing with waste for many years. The Danes were also probably the first nation to recognise the resource potential of waste, rather than continue to treat it as an unfortunate problem as we have done in the UK.

Most, if not all, EfW facilities in Denmark are built close to centres of population, so the waste journey is small (following the proximity principle) and, more importantly, so that the energy produced can be more readily utilised. The electricity produced is used in the local community as is the heat from the thermal process which is distributed in large-scale district heating (DH) systems.

So important is the utilisation of thermal energy from EfW that the Danes have become world leaders in designing pipelines to deliver heat to buildings over unprecedented distances (over 100 km) with negligible temperature drop. By doing this they have also generated an industry in the manufacture of equipment for DH schemes which is world-class.

There are about 400 individual DH schemes in Denmark, of which 350 are consumer-owned and 50 owned by municipalities; the latter, however, cover 60% of the heat supply, so those consumer-owned are much smaller schemes.



IN MOST EUROPEAN COUNTRIES, IT IS NORMAL TO BUILD EFW PLANTS AS PART OF THE COMMUNITIES THAT THEY SERVE.

Historical development: Before 1979 – no laws regulating heat supply

- First DH in Copenhagen in 1930
- DH in larger cities during 1950s and 1960s
- Oil crisis in 1973/74 and end 1970s
- First heat supply act in 1979
 - Planning introduced

Overview of Danish Energy Policy development goals:

1970s Security of supply

1980s Reduced import of fuel

1990s Reduced environmental impact

2000s Energy savings – CO₂ targets

Development process:

1986

- Decentralised CHP became a major energy policy priority
- Biomass and waste to be included as fuels for CHP

1988

- Ban on installing electric heat installations in new buildings – based upon a desire for more efficient energy utilisation
- Extended in 1994 – not allowed to install electric heating installations in existing buildings with water-based central heating systems (protection of public supply areas: DH and gas)

Conversion of DH systems to CHP in three steps:

- **1990–94:** Large coal-gas fired DH plants to natural gas CHP
- **1994–96:** Remaining coal-fired DH to natural gas CHP, medium gas to natural gas CHP, DH outside gas area convert to biomass
- **1996–98:** Smaller DH and apartment blocks (>3 MW) to convert to natural gas CHP

Support measures introduced:

- Copenhagen DH systems to expand DH network (compulsory connection obliged)
- Subsidies to electricity production on gas, biomass, waste, wind
- Fixed electricity 3-tariff systems
- Purchase obligations for CHP-electricity and wind power
- Replaced by a new system in 2005 due to liberalisation of electricity market¹⁶

CAN WE DO WHAT WE PROMISED?

Our EU energy commitments for 2020 become more realistic and achievable if more of the UK's 'waste' is used as fuel resource in EfW plants, which can be designed to produce electricity, heat and/or transport fuels.

On the other hand, virtually any form of recycling requires energy input, which merely increases the UK's energy demand and therefore makes the 2020 targets, which are based on percentages of the total, even more difficult to achieve.

It should also be noted that the frequently made objection that recycling demands less energy than manufacturing from raw material is generally not valid, since the originally manufactured product will almost certainly not have been made in the UK and therefore does not appear in the UK's declared energy consumption or GHG emissions figures.

Along with other European countries, the UK has committed to climate change mitigation targets for 2020, although these are largely represented as CO₂ emissions reduction targets, which is only one way of mitigating climate change, albeit an important one.

The very small penetration of energy produced from renewable resources in the UK (less than 2%), with nuclear currently representing only 5-6% of total energy, means that over 90% of all the UK's energy supply is provided from fossil fuels.

Since fossil fuels are the biggest single contributor to climate change, it follows that increasing energy demand of whatever form will be largely supplied from fossil fuels and will therefore exacerbate, and not mitigate, climate change. EfW, on the other hand, and particularly the high biowaste fraction, is utilising a renewable resource as fuel and is, therefore, making a significant contribution to climate change mitigation.

SO WHAT NEEDS TO BE DONE?

Where do we put waste in the Government?

As mentioned in this report, we have a growing pile of waste which needs dealing with. It is, therefore, a clear connection for most people to see the energy production and waste disposal issues as one which can help solve both problems.

One key reason for this is that Defra has traditionally been responsible for 'waste' issues, whereas BERR was responsible for 'energy'. With the recent Cabinet reshuffle (October 2008), a new Department for Energy and Climate Change (DECC) has been established, merging the energy parts of BERR with the climate change parts of Defra. As explained elsewhere in this report, waste should be regarded as a fuel rather than something which needs to be treated. If this philosophy were agreed, waste would also move from being solely a Defra consideration to being much more of a DECC responsibility. Until this key change is adopted, the waste/energy issues will always fall into the 'cracks' between the two Government departments.¹⁷



WASTE SHOULD BE REGARDED AS A FUEL RATHER THAN SOMETHING WHICH NEEDS TO BE TREATED.

A WASTED SOLUTION TO FUEL POVERTY?

In its most common form, the plant described as EfW will use the combustion process. There is currently in the UK no commercial incentive to build anything other than plants that produce electricity. In common with virtually any other thermal power station in the UK (fossil-fired or nuclear), the enormous amount of thermal energy (heat) produced by the process is simply wasted to the atmosphere. It is simple technology to capture much of this wasted heat and use it for space heating in a district – or community – heating scheme, as is commonly done in most other European countries. Traditionally, the primary objective in building such a plant in the UK is to achieve lowest cost and until this prevailing attitude changes (and a market for heat is created), there is unlikely to be any market inducement to alter this situation.

However, in recent years the UK Government's commitment to eliminating fuel poverty has proven to be widely unsuccessful. Today, with energy costs continuing to rise (nearly 100% increase in costs in the last 12 months), fuel poverty is now on the increase. It is therefore astounding that so many near-continuous sources of heat energy are releasing this heat into the atmosphere. A long-term commitment to make use of this energy by developing community heat networks could offer a viable and direct solution to the fuel-poverty issue, alongside much needed and highly cost-effective measures to improve the insulation and thermal efficiency of our existing housing stock.

Such heat networks are not an immediate or cheap option and will require a long-term programme to implement a network to match that of many other European nations. However, this community/regional programme would provide a sustainable economic benefit to construction and engineering companies, could be initially targeted at high fuel-poverty areas and resolve many local waste disposal issues throughout the UK.

RECYCLE THE MYTHS OF RECYCLING

The UK will never solve its waste issues solely by recycling – there is quite simply too much waste to deal with and too many waste streams that do not benefit from recycling.

Added to this are the continuing outdated and wrongful impressions that EfW systems are simply incinerators that pollute the surrounding areas.

Today, we have the technologies and options available to segregate the waste streams which should be recycled, e.g. metals, from waste that can be used as a valuable and secure energy source. In addition, our addiction to landfills has provided many areas where EfW plants could potentially be constructed.

A long-term reassessment and public education programme on the merits of recycling is required to allow EfW plants to be created to both generate energy for local communities and remove large amounts of waste being produced by the same communities. Looking further ahead, full-scale Waste-as-Resource plants would deal with the vast majority of what we currently still think of as 'waste'.

It's time to put the myths and falsehoods aside and take a fresh look at what we do with our rubbish. Let's not waste any more time, let's not waste any more energy, and let's not waste the opportunity. The time for Energy-from-Waste is now!

- ¹ www.defra.gov.uk/environment/statistics/waste/download/xls/wsr_data_2006.xls
- ² www.recyclezone.org.uk/iz_wastefacts.aspx.
- ³ 'Recycled' is actually defined in these statistics as 'sent for recycling'.
- ⁴ European Council Directive: 1999/31/EC of 26 April 1999 on the landfill of waste.
- ⁵ Statutory Instrument 2002 No. 1559, The Landfill (England and Wales) Regulations 2002.
- ⁶ Scottish Statutory Instrument 2003 No. 235, The Landfill (Scotland) Regulations 2003.
- ⁷ 'Carbon filters' do not filter out carbon (e.g. to mitigate climate change impacts), rather carbon is the material the filters are made of that is used to trap other harmful chemicals.
- ⁸ Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.
- ⁹ Statutory Instrument 2002 No. 2980, The Waste Incineration (England and Wales) Regulations 2002.
- ¹⁰ Implementation of European Council Directive 2000/76/EC on the Incineration of Waste, August 2002.
- ¹¹ Enviro Consulting Ltd and University of Birmingham for Defra, Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes, March 2004, page 256.
- ¹² Defra, Review of England's Waste Strategy: A Consultation Document, February 2006, page 61.
- ¹³ Professor Andrew Porteous, Profit from Waste, Institution of Mechanical Engineers, London 28 October 2004.
- ¹⁴ The latest strategy, 'Waste Strategy for England 2007' does not mention the 'proximity principle'.
- ¹⁵ City Councillor, Peterborough City Council, 11 January 2006.
- ¹⁶ Jan Clement, Team Leader Energy Production, COWI, CHP In Denmark presentation, SEPA Workshop, Edinburgh, 1 September 2006
- ¹⁷ We also suggest that the transport emissions/fuel efficiency parts of the Department for Transport should also come under DECC influence, so that we have a truly joined-up approach to energy and climate change policy.

