Summary

This study provides a brief review of the health and environmental effects of Energy from Waste (EfW) facilities. EfW facilities are also known as "Waste to Energy" facilities, "Energy Recovery facilities," and "waste incinerators". Their purpose is to generate electrical power and/or heat using rubbish (solid waste) as fuel.

This paper aims to describe the use of EfW and its potential effects on health and the environment.

Figure 1: Spittelau Waste to Energy facility, Vienna

Photograph: Stadt Wien

Energy from Waste (EfW) is one of a number of alternatives which can be used to divert municipal waste away from landfill sites. The "Waste Hierarchy" lists the main options in order of preference. The best option is to not produce the waste in the first place, followed by re-use, recycling and composting. EfW is towards the bottom of the waste hierarchy. Like the other options, EfW has both benefits and drawbacks.

The main benefit of an EfW facility is to divert waste away from landfill sites, where biodegradable wastes would otherwise decompose to form landfill gas. Landfill gas may contain trace amounts of hazardous substances, and contributes to global warming. Methane, one of the main constituents of landfill gas, has a global warming potential some 21 times greater than carbon dioxide. The heat created by EfW facilities is used to generate electricity, and can also be used to provide heat for nearby homes and businesses.

The drawbackss of EfW include the production of carbon dioxide, which contributes to global warming. Considerable effort needs to be given to ensuring that emissions are limited to sufficiently low levels as to have no adverse environmental effects. An EfW facility needs to be a part of an integrated waste management strategy. Otherwise, EfW facilities can limit the opportunity to reduce waste, or can be used to dispose of wastes which could have been recycled or re-used.

Energy from Waste makes only a very small contribution to national emissions of potentially hazardous substances – even substances which have received a lot of publicity such as fine particulate matter or dioxins and furans.

There is no consistent evidence of adverse health effects from EfW facilities. If there are any effects, they are at very low levels, and are much smaller than other influences on our health such as passive smoking, diet, or accidents in the home.

Figure 2: Artist's impression of WRG's EfW facility at Allington Quarry, Kent which is under construction

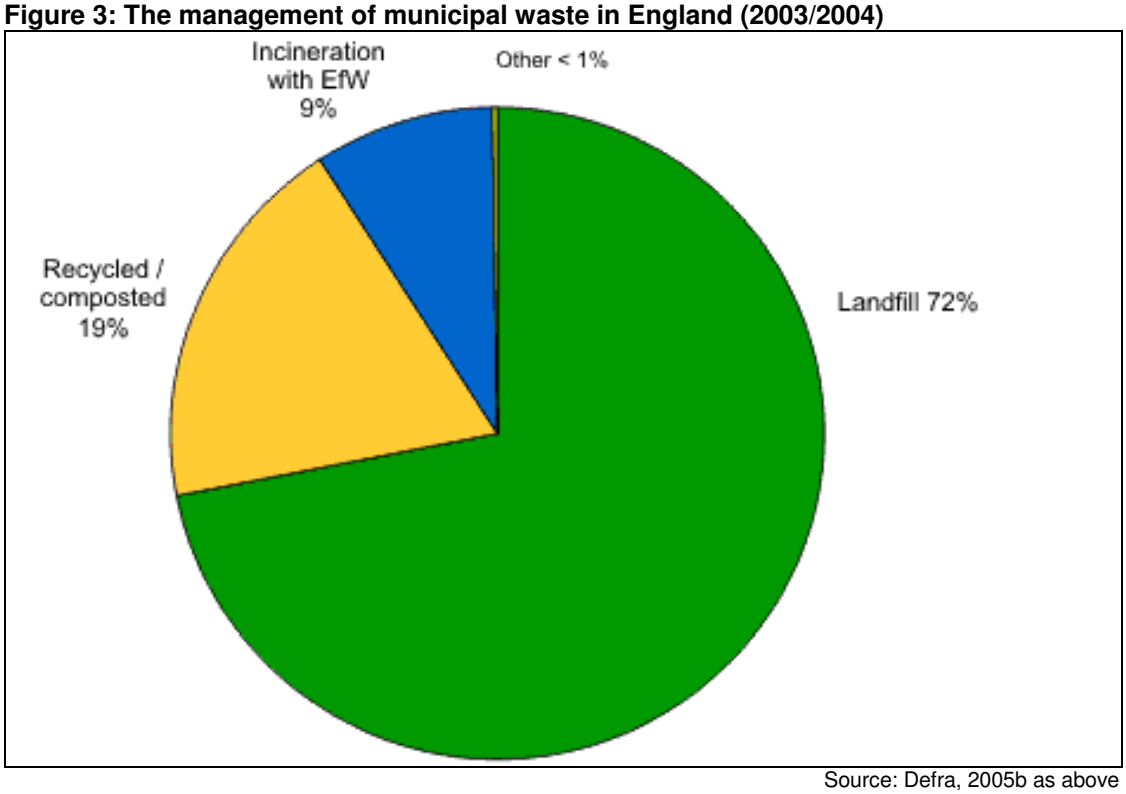
Introduction

The total amount of waste created in UK is around 330 million tonnes per year (DEFRA 2005, "The Environment in your Pocket"). This includes 29 million tonnes of municipal solid waste (MSW) – this is a decrease of 1% from 2002/3 (Defra (2005b), Municipal Waste Management Survey 2003/04).

MSW is collected by or on behalf of local councils. It consists mainly of household waste (79%), together with street sweepings and litter, parks and garden waste and waste from institutions.

Figure 3 sets out the management of municipal waste in 2003/2004. 72% of MSW generated in England was disposed of in landfill sites. Landfill is normally considered to be the least favourable option, and alternatives include recycling, mechanical biological treatment, anaerobic digestion, composting, and thermal treatment (EfW, pyrolysis and gasification). 9% of the UK's municipal waste was incinerated at EfW facilities.

Figure 3: The management of municipal waste in England (2003/2004)



Source: Defra, 2005b as above

There are now a number of drivers for a change in the methods used by the UK to dispose of MSW, and in particular to divert MSW away from landfill sites. The Landfill Directive (1999/31/EC) sets targets for reducing the proportion of waste landfilled. Landfill space is becoming less readily available, and the costs of landfill are increasing. Emissions of methane from landfill sites also make a significant contribution to global warming.

The Landfill Directive requires a progressive reduction in the proportion of biodegradable municipal waste disposed of to landfill. The following limits are set in the Landfill Directive for the reduction in such waste going to landfill sites.

Table 1: Landfill Directive limits.

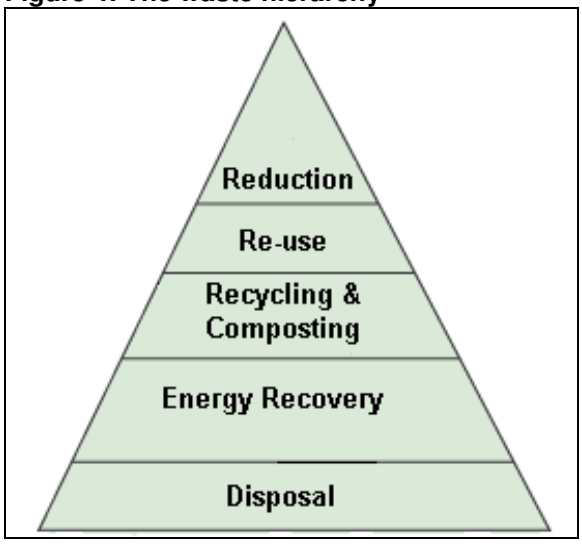
Proportion of biodegradable municipal waste permitted to be landfilled	Year
75% of 1995 quantities	2010
50% of 1995 quantities	2013
35% of 1995 quantities	2020

Local authorities have their own individual targets for reducing the proportion of waste sent to landfill. The cost of not meeting these targets could lead to local authorities being fined

To ensure that these targets are met, a change of approach from waste management to resource management is needed. This will mean that the need to minimise the use of natural resources is built in to all stages of product development, design, manufacture and use.

For managing resources at the end of their useful life, the Waste Hierarchy (Figure 4) is used as a guide for UK waste management strategies. The most desirable option is to not produce the waste in the first place (prevention/reduction). Disposal is the least desirable option. Energy from Waste is part of the energy recovery category of the waste hierarchy, which lies just above disposal.

Figure 4: The waste hierarchy



What is Energy from Waste?

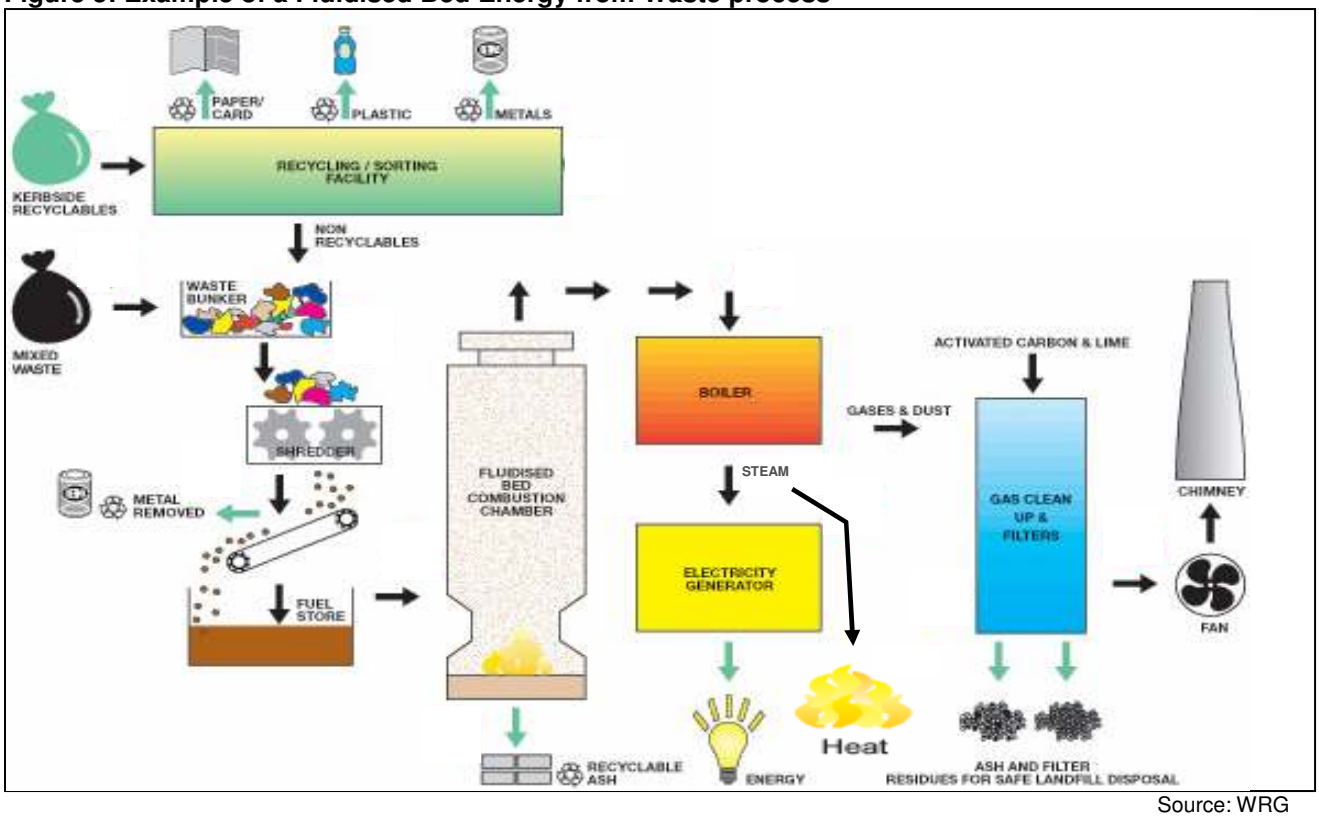
EfW is the controlled thermal treatment of waste by burning, to reduce its volume and/or its toxicity. Energy can be recovered from this process because burning the waste produces useful heat and/or electricity.

Integrated waste management strategies are an important means of balancing sustainable consumption and production, resource efficiency, reduction of greenhouse gas emissions, and practicality. Because EfW facilities require long contracts for financial viability, it is important that they are properly sized, and form part of an overall resource or waste management strategy. If this is not the case, then EfW facilities can restrict the incentives and opportunities for waste reduction – for example, by competing for waste streams such as paper or plastics which could otherwise be recycled. Conversely, a properly thought through EfW process can make an important contribution to sustainable resource use – for example, by fully using the heat and power generated in the process.

EfW facility results in emissions to air – mainly carbon dioxide and water, with lower levels of other substances (see Table 3 below). Incineration reduces the volume of the waste solids by around 90%, and reduces the weight by around 75%. The residual material is bottom ash, with a smaller volume of air pollution control residues (APCRs). About 40% of the bottom ash produced from EfW facilities in the UK is recycled for use in road building, asphalt or breeze blocks. APCRs are usually landfilled because they are alkaline, and contain higher levels of metals.

A variety of technologies are used to extract energy from waste – mass burn, fluidised bed, and gasification technologies are the most widely used. Other factors being equal, larger facilities are more efficient than smaller facilities. The EfW process is shown in a simplified form in Figure 5.

Figure 5: Example of a Fluidised Bed Energy from Waste process



Source: WRG

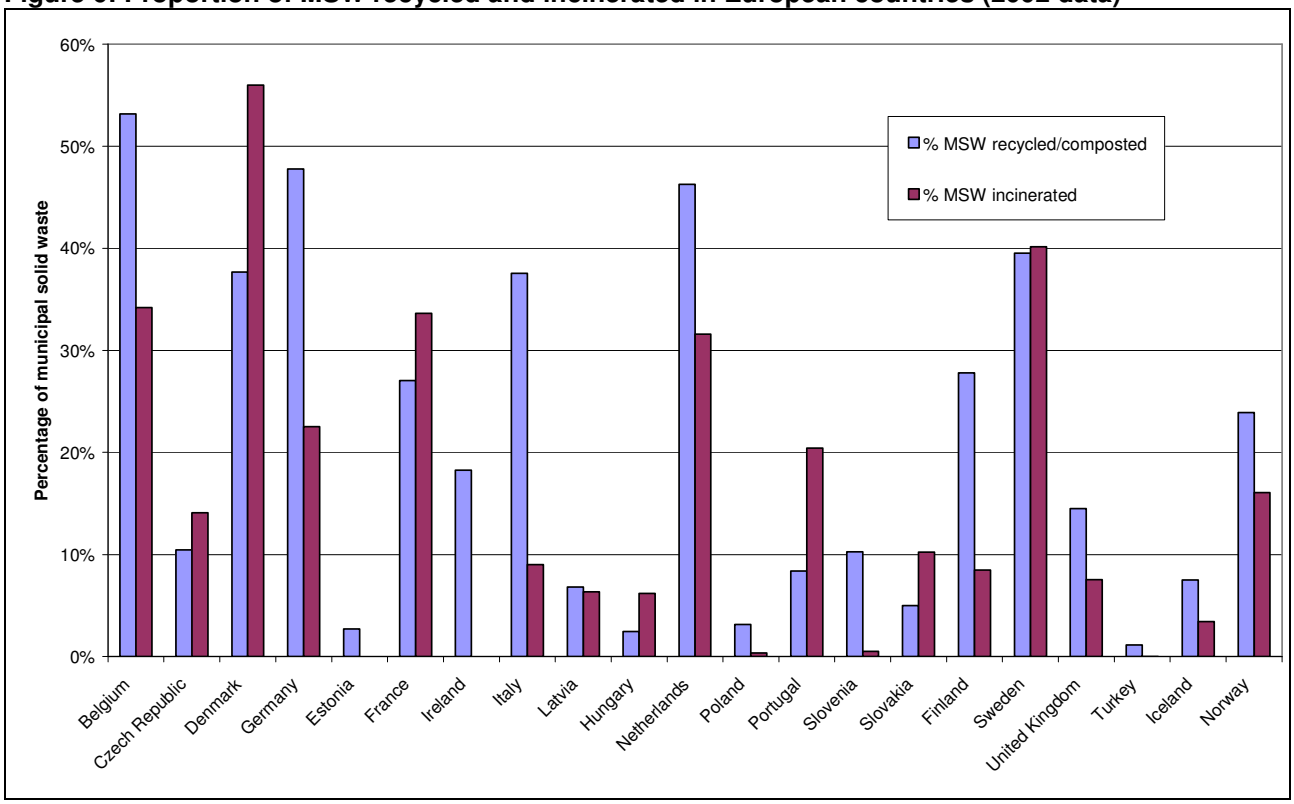
The current capacity (2005) of the twelve EfW facilities in England and Wales is approximately 2.8 million tonnes, with individual facility capacity between 26,000 and 600,000 tonnes per year.

The UK capacity will be increased when WRG's facility at Allington Quarry, Kent is commissioned – this is currently planned for 2006 and will increase the UK capacity by 18% to around 3.3 million tonnes. A more substantial increase in

EfW facilities may be needed over the next ten years, depending on the range of facilities used to meet the reduction targets set in the Landfill Directive.

The UK has a relatively low level of incineration compared to many other European countries as shown in Figure 6. Figure 6 also shows that in countries such as Belgium, Denmark, Germany and Sweden, a relatively high level of incineration can be compatible with high levels of recycling and composting.

Figure 6: Proportion of MSW recycled and incinerated in European countries (2002 data)



(Source: Eurostat (http://epp.eurostat.cec.eu.int), 2005).

Table 2: Benefits and Drawbacks of Energy from Waste

Benefits	Drawback
EfW enables value to be recovered from waste and reduces the amount which would otherwise be sent to landfill. The volume of the waste solids is reduced by around 90%, and the weight by around 75%. The balance is emitted to air mainly as carbon dioxide and water. This helps to achieve the Landfill Directive targets, and reduces the risk of higher global warming emissions due to the formation and release of methane in landfills.	Incineration of waste converts the carbon within the waste into carbon dioxide. This is released into the atmosphere and contributes to global warming.
EfW is an effective way of treating materials that may themselves be potentially harmful (e.g. because they contain micro-organisms), or which if landfilled would produce landfill gas. Landfill gas can contain hazardous substances. It is not straightforward to control and will contribute to global warming due to its methane content.	The emissions to air from EfW facilities result in small environmental and health risks (see below). These emissions need to be reduced and controlled. Reducing emissions to sufficiently low levels requires integrated methods and controlling the emissions at a sufficiently high level presents a challenge to the operators.
EfW facilities recover useful energy from the waste. This can be used to provide electricity to the national grid, and, in some cases, heat for local commercial and/or residential users.	EfW facilities may compete for waste streams which could otherwise be recycled or re-used – for example, paper or plastics.
	EfW facilities require long contracts for financial viability. This means that in some circumstances, an incinerator with excessive capacity can reduce the opportunity for implementing waste reduction measures.

Energy from Waste Emissions

The emissions of greatest significance are set out in the Waste Incineration Directive (2000/76/EC). The substances listed in this directive for emissions to air and water are shown in Table 3.

Table 3: Emissions from EfW facilities.

Substance	Controlled with residual releases to…
Antimony	Air
Arsenic	Air and water
Carbon Monoxide	Air
Cadmium	Air and water
Chromium	Air and water
Cobalt	Air
Copper	Air and water
Dioxins and Furans	Air and water
Hydrogen Chloride	Air
Hydrogen Fluoride	Air
Lead	Air and water
Manganese	Air
Mercury	Air and water
Methane	Air
Nickel	Air and water
Nitrogen Oxides	Air
Particulate Matter (Dust)	Air
Polycyclic Aromatic Hydrocarbons	Air
Sulphur Dioxide	Air
Thallium	Air and water
Vanadium	Air
Volatile Organic Compounds	Air
Zinc	Air and water

(Source: Waste Incineration Directive (2000/76/EC)

Regulation of EfW facilities has tightened in recent years. The Waste Incineration Directive and preceding legislation from the late 1980s required a substantial investment and improvement in emissions controls. This resulted in a significant reduction in emissions from EfW facilities over the past 10 years. For example, over this period there has been an 88% cut in cadmium emissions, a 99% cut in lead emissions and a 97% cut in the emissions of dioxins and furans from waste incineration in the UK (Environment Agency 2003, "Waste Incineration in Waste Management Strategies: Position Statement").

Regulation of EfW facilities became the responsibility of the Environment Agency when it was set up in 1996. The waste incineration directive set further controls on new EfW facilities from 2002, and existing facilities from 2005. All new EfW facilities have needed a permit under Integrated Pollution Prevention and Control since 1998, and existing facilities since 2005.

Careful attention is needed to ensure that emissions from EfW facilities are kept within the permitted levels for that process. Occasionally, emissions from EfW facilities exceed the permitted levels. Incidents of this nature can be a very sensitive issue for local people. It is important that any incidents are investigated and dealt with by the operator and regulator to ensure that they do not recur. However, such incidents do not normally have any significant adverse environmental consequences (Defra, 2004).

Table 4 compares the main emissions to air from UK waste management with other sources.

Table 4: Emissions to air from EfW and other sources in the UK

Substance	UK total emissions	Energy from Waste emissions	EfW as percentage of UK total	Other important sources
Carbon dioxide (partly carbon neutral)	147,500,000 T/year	2,400,000 T/year total (about 1,000,000 T/year fossil origin)	1.6%	**Power generation: 29%**
				Road Transport:21%
				Domestic: 16%
Methane	2,427,000 T/year	50 T/year	0.002%	**Agriculture: 40%**
Fine particles (PM_{10})	172,000 T/year	90 T/year	0.05%	Power generation: 13%
				Road Transport:15%
				Domestic: 16%
Oxides of nitrogen	1,512,000 T/year	4,000 T/year	0.3%	Power generation: 24%
				Road Transport: 42%
Sulphur dioxide	1,165,000 T/year	102 T/year	0.01%	**Power generation: 71%**
Dioxins and furans	360 g/year	1.9 g/year	0.53%	Fireworks: 14%
				Accidental fires: 16%
PCBs	1706 kg/year	0.2 kg/year	0.01%	**Old electric equipment: 70%**
Arsenic	34.6 T/year	0.01 T/year	0.035%	**Domestic: 21%**
Cadmium	5.2 T/year	0.01 T/year	0.23%	**Metals manufacture: 44%**

Source: DEFRA (2004), Review of Environmental and Health Effects of Waste Management: MSW and Similar Wastes

Table 5 shows some of the emissions from an EfW facility accepting around 230,000 tonnes per year of MSW (typical size for the UK). The table also shows a comparison source which would result in a similar amount of emissions of each substance.

Table 5: Emissions from a typical EfW facility

Substance	Annual emissions to air from typical EfW facility	Approximately equivalent to annual emissions from
Carbon monoxide	70,000 kg	A 1 km stretch of a typical motorway
Volatile organic compounds	1800 kg	A 0.3 km stretch of a typical motorway
Oxides of nitrogen	370,000 kg	A 7 km stretch of a typical motorway
Fine particles (PM_{10})	8,000 kg	A 5 km stretch of a typical motorway
Carbon dioxide (partly neutral carbon; partly fossil fuel origin carbon)	220,000 tonnes total (about 90,000 tonnes fossil origin)	A 28 km stretch of a typical motorway An 11 km stretch of a typical motorway (fossil origin carbon only)
Methane	4630 kg	A herd of 100 cows
Sulphur dioxide	9,000 kg	100 homes using coal fires for heating
Dioxins and furans	0.18 grams	Accidental fires in a town the size of Milton Keynes
Arsenic	1.2 kg	Less than a fiftieth of the emissions from a medium sized (970MW) UK coal-fired power station
Cadmium	1.2 kg	Less than a twentieth of the emissions from a medium sized (970MW) UK coal-fired power station

Source: Enviros, 2005 drawing on Defra 2004 (as above) (information on EfW emissions)

The potential health effects of EfW in context

Studies into the incidence of ill-health in people living close to waste incinerators have been carried out for many years. These studies are difficult to carry out, because of:

- The relatively small population sizes which are potentially affected by emissions from individual incinerators;
- The relatively low incidence of the health outcomes of concern;
- The difficulties in representing exposure to the incinerators;
- The substantial reduction in emissions from incinerators over the periods most widely studied;
- The time lag which occurs between exposure to an environmental pollutant and the occurrence of a health outcome such as cancer;
- Other causes of ill-health, the effects of which can't be distinguished from the effects of an EfW facility (such as emissions from nearby industrial processes) (these are referred to as "confounding factors"); and
- The difficulty of identifying comparable control populations.

Three broad categories of potential health effects have been investigated. These are a link between EfW and:

- Respiratory diseases;
- Cancer and
- Reproductive problems.

Most studies of respiratory health are based around older incinerators with higher emissions, and use self-reported symptoms. There is no consistent pattern of increased symptoms around incinerators, as would be expected from the results of emissions surveys, air quality monitoring surveys, and risk assessment studies. These show that incinerators are not a major contributor to ambient air pollution, and would be unlikely to contribute to a detectable increase in the rate of respiratory disease in people living nearby.

Many studies have been carried out into the incidence of cancer and reproductive problems in populations living near to incinerators. These studies have not found consistent or convincing evidence of a link between cancer and the current generation of EfW facilities. Partly, this is because incineration facilities have been operating to the demanding current standards for a relatively short period of time. However, it is also because the studies do not give clear evidence for a link between the incidence of cancer and proximity to EfW facilities – even for older facilities. Because emissions from modern

EfW processes are at a much lower level, it is even less likely that there would be any significant link between EfW facilities as currently operated in the UK, and the incidence of cancer.

A similar picture emerges for reproductive problems. While there is limited evidence for a link with older and poorly designed/operated facilities, there is no clear overall picture and the studies are likely to be strongly influenced by other causes of ill-health (confounding factors).

Any effects on reproductive health from current MSW incinerators are likely to be at a much lower level than the low level of health effects observed from the earlier studies, and at a lower level than other factors which influence health, such as diet, exposure to pollutants from road traffic and domestic sources, and smoking habits.

A study carried out by Enviros for Defra (Defra, 2004 as above) compared the health effects which can be linked with confidence to emissions from EfW processes, to the health effects associated with other environmental factors (Table 6). While there may be other health effects which cannot be quantified in this way, the information in this table confirms that the effects examined are low in the context of other effects on health.

Table 6: Comparison of the health effects of EfW emissions to air with other environmental factors

Health effect	Approximate estimate of number per year in the UK due to					
	EfW emissions to air	Skin cancer	Lung cancer due to passive smoking	Air pollution (all sources)	Road traffic accidents to pedestrians	Accidents in the home
Number of people whose life is shortened	0.15	Not available	Not available	11,600	671	4,300
Hospital admissions	4	Not available	Not available	14,000	32,000	168,300
Cancers	0.0005	6,000	Several hundred	-	-	

DEFRA (2004), Review of Environmental and Health Effects of Waste Management: MSW and Similar Wastes; Department for Transport, Transport Statistics for Great Britain

Conclusion

This study provides a review of Energy from Waste. Its aim is to describe the use of EfW facilities in the UK, and their potential effects on human health and the environment.

- EfW is towards the bottom of the waste hierarchy, being preferable to disposal of waste (e.g. in landfill) but less favourable than other waste management options such as recycling.
- EfW diverts waste away from landfills, reducing the production of hazardous and greenhouse gases.
- EfW facilities can in some circumstances reduce the opportunity to reduce, re-use or recycle waste. This can be addressed under an integrated waste management strategy, which is likely to indicate a limit on the size of an EfW facility so that reducing, re-using and recycling are not constrained.
- The heat created by EfW facilities is used to generate electricity, and can also be used to provide heat for nearby homes and businesses.
- Careful attention is needed to ensure that EfW processes are properly operated within regulated limits.
- EfW produces carbon dioxide, which contributes to global warming.
- EfW processes make no more than a very small contribution to national emissions of potentially hazardous substances.
- There is no consistent evidence of adverse health effects from EfW facilities.

Web Links

Waste Recycling Group: www.wrg.co.uk

Enviros Consulting Limited: www.enviros.com

Review of Environmental and Health Effects of Waste Management: municipal solid waste and similar wastes (prepared for Defra by a consortium led by Enviros): www.defra.gov.uk/environment/waste/research/health/

Municipal Waste Management Survey 2003/04 (Defra): http://www.defra.gov.uk/environment/statistics/wastats

Environment Agency: www.environment-agency.gov.uk/aboutus/512398/289428/653535

National Society for Clean Air and Environmental Protection: www.nsca.org.uk

Greenpeace review of incineration and human health: http://archive.greenpeace.org/toxics/reports/reports.html

Audit statement by the National Society for Clean Air and Environmental Protection

Summary
The note provides a useful briefing, though the level of supporting evidence and discussion is variable. Emissions and health impacts receive a more detailed treatment than resource management.

Conclusions

- ***Is the paper fair and balanced?***
  The paper provides a good comparison of EfW with other forms of waste management. It gives good account of the emissions and health implications of EfW facilities and puts these in context by raising important resource management issues.
- ***Does the paper reflect the current state of scientific knowledge?***
  Regarding the emissions and health benefits, the arguments presented reflect NSCA's own understanding of the issues.
- ***Are the conclusions supported by the evidence?***
  The conclusions regarding emissions and health implications of EfW facilities are based upon data, sourced from reputable studies. Other conclusions are supported by limited or no evidence or discussion.

Signed by Rob Pilling *Rob Pilling, Policy Officer, NSCA* *Date: January 2006*