INCINERATION OF HOUSEHOLD WASTE

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- ***Possible increase in waste incineration***
- ***Concerns over pollution***

Recent national waste strategies have led to the suggestion that the numbers of waste incinerators may increase significantly. This raises concerns over the health effects of pollution and the role of incineration in waste management.

BACKGROUND

Each year UK households generate around 30 million tonnes of municipal solid waste (MSW)[1] (**Table 1**). The Department of the Environment, Transport and the Regions (DETR) reports that this figure appears to be growing at about 3% per year. Management of MSW in the UK is dominated (83%) by landfill disposal (Table 1), with less than one tenth either incinerated or recycled[2].

There are 13 MSW incinerators (MSWIs) operating in Britain (there are none in Northern Ireland), burning around 2 million tonnes of MSW each year (8% of the total). All MSWIs recover some of the energy from combustion as electricity or in district heating. As such, these facilities are known as 'energy from waste' (EfW) or 'waste to energy' plants. Current facilities range in size from a plant in Lerwick, handling 26,000 tonnes per year (26kt/yr) and producing heat for a local district heating system to a 600kt/yr facility at Edmonton, generating 30 megawatts (MW) of electricity. Over half of all current incinerators handle more than 200kt/yr, and 40% between 100 and 200kt/yr.

MSWIs operate by feeding wastes onto a moving grate where they are burned. The heat generated raises steam, driving turbines to generate electricity. The burning of the waste gives rise to:

- solid **incinerator bottom ash** (up to 25% of the weight of the MSW) - which falls to the bottom of the grate for collection. This is either disposed of to landfill or reused in construction.
- a very much finer **fly ash**, caught up in the **flue gases** (air and gaseous combustion products).

Box 1 outlines the current technology for waste incineration, and the main developing technologies. Information provided by the Energy from Waste Association (EWA) shows that additional incinerator capacity of ~4 million tonnes/yr is currently being considered - more than doubling existing capacity (**Table 2**).

TABLE 1 WASTE TREATMENT IN THE UK

Region	MSW (million tonnes/yr)	Landfill	Recycling and reuse	Incineration
England & Wales	28	82%	10%	8%
Scotland	3	90%	5%	5%
N. Ireland	1	95%	5%	0%
Total	**32**	**83%**	**9%**	**8%**

Sources: DETR, Scottish Environment Protection Agency, Environment and Heritage Service Northern Ireland

BOX 1 WASTE INCINERATOR TECHNOLOGY

There are four main technologies for the incineration of waste.

Mass Burn – This is currently the simplest and most common form of incineration. Mixed wastes are fed into a hopper and then fall onto a sloping grate which agitates and moves the waste through the combustion chamber. Energy is recovered from the hot combustion gases, which is used to generate around 7MW of electricity per 100,000 tonnes of waste (enough electricity to serve around 10,000 homes).

Fluidised Bed Combustion (FBC) – Before the waste is incinerated, non-combustible components are removed and the waste shredded to produce coarse Refuse Derived Fuel (cRDF) which has a higher calorific value than the untreated waste. The cRDF is fed into a bed made up of a mixture of sand and dolomite mineral. Air is pumped through the base so that the solid waste and minerals resemble a bubbling liquid. This 'fluidisation' improves the combustion efficiency, hence reducing pollution and generating more energy per tonne of waste. However, the process is between 25% and 35% slower than mass-burn. To date there has been limited experience with using FBC for municipal waste incineration, and the performance of this technology has not been proven on a commercial scale. In Berlin, a new FBC waste incinerator has been closed down because of reliability problems.

Pyrolysis and Gasification – These novel technologies have had limited experience in treating municipal waste. Wastes do not need sorting, but must be crushed, and this pre-treatment leads to higher costs and uses more energy.

- **Pyrolysis** involves heating waste in the absence of oxygen at temperatures of 400-800°C. The heat alone breaks down complex molecules and the resultant gases are then passed into a combustion chamber where they are burned (in the presence of oxygen) at temperatures around 1250°C.
- **Gasification** involves heating wastes in a low-oxygen atmosphere to produce a gas with a low energy content. This gas can then be burned in a turbine or engine.

There are only a few pilot pyrolysis and gasification plants worldwide - in Japan and Germany – but the technology has not yet been proven to be commercially viable. A pilot scale gasifier is being built in Bristol with a capacity to burn 9kt/yr of MSW.

POLLUTANTS FROM INCINERATION

The main pollutants of concern are dioxins, acid gases, nitrogen oxides, heavy metals and particulates (**Box 2**). These are present in bottom ash, fly ash and combustion gases[3], although flue gas cleaning reduces pollutant emissions to the air to a large extent. Fly ash can contain sufficient dioxins and metals to require it to be treated as a

[1] The total for municipal, industrial and commercial wastes is ~70 million tonnes
[2] many countries recycle and incinerate a larger proportion of waste than the UK.

[3] There are also pollutants present in liquid effluents arising from gas cleaning and ash cooling equipment.

TABLE 2 ENERGY FROM WASTE PLANTS IN THE UK

Status (as at Feb 2000)	waste capacity (kt/yr)
Operating (or being upgraded)	2,706
Under construction or planning granted	790
Firm contract subject to planning	1,285
Proposed	1,630
Total	**6,411**
% increase in capacity relative to current operating (and upgrading) capacity	137%

Source: Energy From Waste Association

BOX 2 MAIN POLLUTANTS FROM WASTE INCINERATION

Gases – acidic gases (such as hydrogen chloride, hydrogen fluoride and sulphur dioxide), and other gases such as nitrogen oxides, carbon monoxide and carbon dioxide[4].

Metals – in particular cadmium, mercury, arsenic, vanadium, chromium, cobalt, copper, lead, manganese, nickel, thallium, tin. These are present as soluble compounds (such as chlorides and sulphates), and less soluble compounds (such as oxides and silicates). Mercury, and some cadmium, is released as vapour.

Organic substances – these are often present where combustion has not been complete, or are formed after incineration has occurred. The organic compounds may be released as vapour or bound to particulates. Dioxins are the organic pollutants that attract most concern (Box 3).

Particulate matter – fine particles (often of inorganic materials such as silica), frequently with metals and organic compounds on their surfaces. They vary greatly in size, but recently, concern has focussed on ultrafine particles of less than 10 millionths of a metre (10 microns) – these are known as PM_{10}.

hazardous waste. However, it is the presence of pollutants in the gases emitted from MSWI chimneys that attracts most concern, and in particular, the presence of dioxins (**Box 3**) because they are suspected of causing cancer and are widely distributed throughout the food chain.

Of other air pollutants, acid gases and particulates, for instance, can harm people with respiratory illnesses. A report[5] from the Department of Health's Committee on the Medical Effects of Air Pollution (COMEAP) concluded that PM_{10} pollution from all urban sources hastens ('brings forward') 8,100 deaths/yr, and increases or brings forward hospital admissions by 10,500/yr.

REGULATING INCINERATORS

The Environment Agency (EA) in England and Wales, and the Scottish Environment Protection Agency (SEPA) regulate releases to the environment from MSW incinerators under the integrated pollution control (IPC) regime. Releases must be prevented. or reduced to a minimum using the 'best available techniques not entailing excessive cost'. When authorising processes, the EA and SEPA impose limits on a range of substances released to air water and land, together with conditions on operation (e.g. regular monitoring). MSW incinerators were first authorised under IPC in 1993, and new EU standards imposed in 1996, resulting in the closure of many older incinerators.

A new EU waste incineration directive (agreed in 2000), introduces tighter standards, including an emission limit on dioxins of 0.1 nanogrammes[6] of TEQ per cubic metre of exhaust gas ($ngTEQ/m^3$) – equivalent to $100pgTEQ/m^3$ (Box 3). The incineration directive requires that new incinerators comply with the standards from 2003 and existing plant from 2006[7].

The siting of incinerators is regulated under the land use system, where the operator must obtain permission from the local planning authority. In determining the *planning* application, the local authority must have regard for, among other things, environmental impacts, and hence requires the developer to produce an environmental impact statement. In addition, the local authority will consult the *environmental* regulator (EA or SEPA). The recent Pollution Prevention and Control Regulations will require closer coordination and consultation between the environmental regulators and local authorities responsible for land use control. Increasingly, local authorities are developing waste local plans in a regional context, taking account of regional planning guidance.

ISSUES

Waste Management Policy

The Waste Strategies for England and Wales and for Scotland, have led to concerns that the number of incinerators across Britain will increase. Indeed, the Department of the Environment, Transport and the Regions has calculated[8], based on a range of waste management scenarios, that anywhere between 28 and 165 new average-size incinerators may be needed over the next 20 years in England and Wales[9] to meet targets for diverting wastes from landfill set out in the EU Landfill Directive.

[4] In its 17th report (1993), the Royal Commission on Environmental Pollution calculated that incineration with energy recovery is a net emitter of greenhouse gases (carbon dioxide). However, it showed that, compared with landfill (which produces methane and carbon dioxide), incineration reduces overall greenhouse gas emissions.
[5] *The Quantification of the Effects of Air Pollution on Health in the United Kingdom.* http://www.doh.gov.uk/hef/airpol/airpol7.htm

[6] 1 nanogramme is one billionth of a gramme
[7] most UK MSW incinerators comply with these standards, but upgrades will be necessary for many to comply with emission limits on nitrogen oxides.
[8] House of Lords European Union Committee 7th report Session 1998/99 (para 101).
[9] There are no comparable figures in the waste strategy for Scotland

BOX 3 THE HAZARDS OF DIOXINS

What are they? - Dioxins is the name given to a group of 210 similar chlorinated organic chemicals.
Health Effects – Dioxins may cause adverse health effects, depending on the level, timing, duration and frequency of exposure, the particular compounds, and the susceptibility of the person exposed. Most concern is expressed over the link between long-term exposure to dioxins and the risk of cancer. Studies have also suggested dioxins may cause reproductive or developmental effects, e.g. abnormal physical development, weakened immune responses and behavioural changes.
Standards - It is unclear whether there is a threshold below which exposure to dioxins will have no effect. The US Environmental Protection Agency (US EPA) assumes that no such threshold exists and sets precautionary standards accordingly. The World Health Organisation (WHO) and the UK Department of Health's advisory committees[10] assume there is a 'no-effect' threshold, and thus set slightly less stringent standards (see below). Standards for allowable levels of dioxins in foods are based on the concept of 'tolerable daily intakes' (TDIs). Because different dioxins vary in their toxicity, standards are also expressed in terms of toxic equivalents (TEQ). A TEQ of 1 relates to the most toxic dioxins - others have lower TEQs. US EPA uses a TDI of 0.1 picogramme[11]/kilogramme body weight/day (pgTEQ/kg.bw/d), whereas the WHO recommends a TDI of 1-4pgTEQ /kg.bw/d. The UK standard is currently 10pgTEQ/kg.bw/d, but is being reviewed.
Exposure – 98% of people's exposure to dioxins comes through the food chain (direct inhalation accounts for the remaining 2%). In 1997 (the most recently available data), 3% of dioxin emissions came from MSW incinerators. Dioxins are deposited from the air onto crops, grazing land and soil, and are passed through the food chain to be ingested. They are also washed off the land into the sea and taken up by fish. They are widespread in the environment, and minute levels are likely to be found in all foods. However, exposure may increase because of people's proximity to particular sources, or through dietary habits – e.g a large consumption of oily fish, red meat, dairy produce, or breast milk for nursing infants. Because dioxins are chemically inert, they are not readily broken down and can accumulate in the body (particularly in fatty tissues). Current levels of exposure may be sufficient to cause some adverse impacts in the general population, although research has found no clear evidence of this. Both the US EPA and WHO acknowledge that such effects may be occurring but are not observable because they are 'masked' by the background of 'normal' disease. Studies investigating health effects and dioxin exposure in specific locations (e.g. the area surrounding waste incinerators) have also yielded inconclusive results.

Sources: US EPA, WHO, COC, COM.

DETR regards the high end of this range to be unlikely, and evidence to the Commons Environment Sub-Committee from the EWA and from Enviros consultants suggests that up to around 50 new plants will be needed by 2015. The precise final figure will depend on trends in waste production, success of reduction, reuse and recycling schemes and size of plant.

An important element in UK waste management policy is the 'waste management hierarchy'. This prioritises waste management options, so that the option with the lowest environmental cost should have first refusal. As such, the first priority is to minimise the production of waste, followed by reuse, recycling and recovery, and finally disposal. In this hierarchy incineration with energy recovery needs to be considered before landfill. The Waste Strategy for England and Wales makes it clear that waste incineration without energy recovery will be regarded as disposal, effectively requiring any incinerator proposal to include it. The strategy signals that incineration may form part of a comprehensive waste management package but that local authorities should sanction the use of waste incineration only where options higher in the hierarchy have been exhausted and where energy recovery can provide a benefit in terms of locally-supplied electricity, district heating (or both).

Overall, waste management is founded on developing a mix of waste management options that represents the Best Practicable Environmental Option (BPEO). This means that the environmental impacts of a local authority's waste plan should be minimised within the bounds of technical and economic feasibility. However, it is not made clear in the Waste Strategy how the BPEO for waste management should be identified.

There is a range of opinion among environmental campaigning groups[12] regarding the place of incineration in waste management. The National Society for Clean Air and Environmental Protection argues for incineration to play a part in a comprehensive strategy that includes waste reduction, reuse and recycling. Waste Watch agrees, but wishes to see these other options maximised before adopting incineration. Concerns remain, however, that there is no definitive guidance on how waste planning authorities can prove that options higher in the hierarchy have been exhausted before adopting incineration.

Other groups (e.g. Greenpeace and Friends of the Earth) argue that there is little or no place for incineration in waste management. They allege that the pollutants released present an unacceptable risk to health and are concerned that commitment by local authorities to long-term contracts for supplying waste to incinerators will undermine efforts to reduce waste at source, and to recycle and reuse residual wastes[13]. Lastly, some groups reject

[10] Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT), Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC), and Committee on Mutagenicity of Chemicals in Food, Consumer Products and the Environment (COM).
[11] 1 picogramme (pg) is one trillionth of a gramme

[12] See evidence to House of Commons Environment Sub-Committee inquiry into *Delivering Sustainable Waste Management,* October 2000.
[13] However, there is evidence from overseas showing that recycling and incineration can occur within a comprehensive waste management programme - Petts, J., Planning for sustainable waste management, in Miller, C. (ed) *Planning and the Environment*, in press

the classification of energy from waste as a form of renewable energy – this is highly contentious, but is beyond the scope of this briefing.

Regulatory Issues

The role of the environmental regulator

The potential impacts of pollutant releases on health raise concerns, most often related to whether there is a 'safe' dose of dioxins. While the International Agency on Cancer Research (IARC) classifies dioxin as carcinogenic to humans, uncertainty remains over how dioxin causes cancer, and at what level it may be carcinogenic or have other effects. Recognising this uncertainty, the EU adopted a precautionary approach in setting the dioxin emission limit value. But, this level has not been set on the basis of an assessment of what might be considered a 'safe' dose – i.e. it is not related to any specific TDI (Box 3). Instead, the limit was set so that reliable measurements can be made by available detection equipment.

This means that regulating emissions relative to the emission limit does not guarantee that emissions are at a safe level. Rather, regulation to protect health has to rely on mathematical models of the dispersion, deposition and uptake of dioxins, and the consequent levels of exposure in relation to the TDI. Each element in the model relies on assumptions and can introduce large uncertainties. This raises concerns over whether the setting and enforcement of standards, and process authorisation fulfil the Agencies' requirement to protect human health. However, modelling worst-case situations helps to take account of many uncertainties.

Critics of incineration have suggested that more than 500 deaths would be brought forward over the operating life of an incinerator. However, this figure has now been shown to be erroneously too high[14]. Even so, such an analysis, based on extrapolation of the COMEAP report would not produce an accurate figure for any specific incinerator, as it does not take account of local conditions, such as the:

- location of pollutant sources and those receiving the pollution.
- the pathways of exposure (e.g. the transport of dioxins through the food chain).
- how susceptible people are to particular pollutants (e.g. the old, young or infirm).

[14] following recalculation by consultants of the cost-benefit analysis in the DETR's Regulatory and Environmental Impact Assessment on the Proposed Waste Incineration Directive.

BOX 4 INCINERATOR PLANNING AND THE PUBLIC

Examples of including the public in decision-making include:

- **Dundee Energy Recycling Ltd** has signed the UK's first 'Good Neighbour Charter' committing the company to adopting environmental standards stricter than currently required by law.
- the **SELCHP** incinerator in southeast London, involved local people working with the developers and planners, and a member of the local community sits on the management board.
- Following a previously failed plan, **Hampshire County Council** set up a number of citizens' panels to examine issues related to waste in the county and has worked with them to develop a mix of options that includes composting, recycling and small-scale incineration. This plan has met with wider public acceptance.

The role of local authorities

Local authorities produce statutory 'waste local plans', act as waste collection authorities, waste disposal authorities, and as local planning authorities. The Local Government Association (LGA) and the Planning Officers Society have expressed concerns that there is very poor coordination between these functions. This can be particularly acute where these responsibilities are split between counties (waste planning) and districts (collection, disposal and land use control).

Public Concerns and Acceptability

Local opposition to incinerators is often strong. Concerns arise over whether an incinerator is:

- justified in relation to reduction, reuse and recycling of wastes.
- sited and sized appropriately – e.g. if it deals only with wastes originating locally, and if it is located in a deprived area (raising issues of environmental justice).
- regulated to sufficient environmental standards, and that these standards are enforced adequately – i.e. whether the regulator can be trusted as independent and competent.

Such concerns are frequently characterised as NIMBYism (Not in My Back Yard). However, research shows that people's concerns often stem from the way that MSWIs are planned and consultation conducted. In particular, opposition arises when people feel excluded from decision-making and have decisions imposed upon them. Acceptability is increased if local people are involved early in planning (**Box 4**), including in the regional and waste local planning process. The DETR makes this point in recent guidance, and is fully supported by the LGA and the EWA, who now regard this process as the 'norm'.