Summary of the air quality and health effects of Energy from Waste facilities

Report for SKM Enviros on behalf of London Borough of Sutton
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Executive summary

AEA Technology was commissioned by SKM Enviros on behalf of the London Borough of Sutton to summarise current knowledge on the air quality and health effects of Energy from Waste (EfW) facilities as currently practised in the UK.

Background

Waste incinerators have been in existence for over 100 years. However, incineration was a largely unregulated activity until the introduction of the Municipal Waste Incineration directives of 1989, and emissions limits and controls were further tightened following the introduction of the Waste Incineration Directive in 2000. To comply with the requirements of the Waste Incineration Directive, waste incinerators are now required to reduce residual emissions of these substances to much lower levels than those which took place before the implementation of the Directive.

All new EfW facilities burning municipal waste need a permit under the Environmental Permitting regulations. The Environmental Permitting system is the means by which EfW facilities are regulated to ensure that risks to the environment are prevented or minimised. The applicant is required to submit a detailed application which describes the controls on environmental pollution, and includes an assessment of the environmental and health effects of these emissions. This application is reviewed by the regulator in consultation with statutory and non-statutory bodies including members of the public.

If the Environment Agency is satisfied that the plant will be designed, constructed and operated in a way that will not significantly pollute the environment or harm human health, then a permit can be issued. If a permit is issued, it contains a series of legally binding conditions covering the plant and equipment, as well as wider issues such as staff training and management, monitoring and record keeping.

Air quality issues

Emissions to air from incineration of municipal waste in the UK gives rise to minor contributions to levels of air pollutants. A facility of the scale proposed for the London Borough of Sutton would result in emissions to air which are comparable with many familiar sources. For example, emissions of dioxins and furans from the proposed facility would be expected to be similar to emissions from accidental fires in the borough, although emissions from an EfW facility would be subject to much better control and would result in much lower public exposure.

EfW facilities are fitted with process and emissions monitoring equipment. Continuous monitoring is carried out of a wide range of emissions, including substances of concern with regard to potential effects on health such as oxides of nitrogen and particulate matter. Other substances such as dioxins and furans and metals cannot be measured continuously. Emissions to air of these substances are controlled by ensuring good combustion conditions in the process together with well designed and operated air pollution control supplemented by periodic measurements to ensure that the expected performance is being maintained.

The substances emitted to air from EfW facilities which give rise to plausible concerns with regard to air quality are as follows:

- Nanoparticles/ultrafine particles
- Dioxins and furans
- Trace metals
- Nitrogen dioxide
- Emissions during abnormal operating conditions

EfW facilities make a small contribution to environmental levels of ultrafine particles, and a similarly small contribution to airborne levels of larger particles. Modern municipal solid waste (MSW) incineration facilities emit much lower levels of dioxins and furans than those from incineration facilities in the past – a reduction of over 99% since 1990. This means that MSW incineration is now no longer a significant source of emissions to air of dioxins and furans, contributing only 2.5% of UK emissions. More significant sources include accidental fires and open burning of waste, agricultural straw burning, the iron and steel manufacturing industry, and crematoria.

EfW facilities can make a more significant contribution to environmental levels of trace metals and nitrogen dioxide. This contribution needs to be taken into account in the design of new EfW facilities, to ensure that no emissions are forecast to have any significant effects on air quality or the health of people living and working in the local area. The design process needs to take account of baseline air quality to ensure that a new EfW facility does not compromise a local authority's ability to fulfil its obligations in respect of local air quality management.

Abnormal operating conditions can affect emissions to a limited extent. These situations need to be taken into account during the planning and permitting process, but do not normally have any significant adverse environmental consequences.

Health issues

The key health issues of potential concerns are:

- Carcinogens and cancer risk
- Infant mortality
- Infant development problems

While there is always some uncertainty in the findings of health studies, it is concluded that well-designed EfW facilities as currently operated in the UK are most unlikely to have any significant or detectable effects on cancer incidence, infant mortality, or the incidence of adverse birth outcomes.

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2 Introduction

AEA Technology was commissioned by SKM Enviros on behalf of the London Borough of Sutton to prepare a summary of the air quality and health effects of Energy from Waste (EfW) facilities.

The study takes account of the findings of reviews published by bodies such as the Health Protection Agency and Scottish Environmental Protection Agency/NHS Scotland. A search for more recent scientific literature was also carried out.

The report is structured as follows:

Chapter 2: Summary of relevant air quality issues

Chapter 3: Summary of relevant health issues

Chapter 4: Conclusions

This study does not address the issue of whether energy from waste is an appropriate form of waste treatment at a strategic or a local level.

In this report, the term “Energy from Waste” is used interchangeably with “Incineration.” Generally, “incineration” is used to refer to facilities operating prior to the implementation of the Waste Incineration Directive. The implementation of this directive required the recovery of energy as heat and/or electricity. Consequently, facilities operating after the implementation of the Waste Incineration Directive are generally referred to as “Energy from Waste” facilities.

3 Energy from Waste facilities

3.1 Historical context

The term “waste incineration” describes the process by which the combustible components of waste materials (such as organic materials and plastics) are burnt under controlled conditions. Carbon and hydrogen in the waste are converted to carbon dioxide and water respectively, and consequently the main components of emissions from a waste to energy facility are carbon dioxide and water, together with nitrogen and oxygen from the air.

A number of other substances are formed during the combustion process, of which the main constituents are acid gases – oxides of nitrogen (made up of nitric oxide and nitrogen dioxide), sulphur dioxide, hydrogen chloride and hydrogen fluoride. Small quantities of particulate matter, carbon monoxide and volatile organic compounds are present in the flue gases. Much lower quantities of metals are also present, together with smaller quantities still of partial combustion products such as dioxins and furans, polychlorinated biphenyls and polycyclic aromatic hydrocarbons. The residual component of the combustion process and non-combustible components of the waste, such as metals and minerals, are removed from the incinerator as ash. Ash is also produced from the air pollution control systems.

Waste incinerators have been in existence since the late 19th century, but incineration was a largely unregulated activity until the introduction of the Municipal Waste Incineration directives of 1989 (89/429/EEC and 89/369/EEC). These directives laid down operational requirements and some emissions limits on waste incineration facilities. Emissions limits and controls were further tightened following the introduction of the Waste Incineration Directive (2000/76/EC), and the implementation of Integrated Pollution Prevention and Control (IPPC).

These changes represent a major change in waste incineration since the development of a previous generation of facilities in the 1960s. The changes in design and operation of waste incineration facilities over this period must be taken into account when interpreting the findings of health studies, and are also relevant in understanding public views and perceptions of waste incineration.

3.2 Regulation of EfW facilities

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. Since 1998, all new EfW facilities burning municipal waste have needed a permit under the Environmental Permitting regulations and the predecessor arrangements, Integrated Pollution Prevention and Control (IPPC) and Integrated Pollution Control (IPC).

The Environmental Permitting system is the means by which EfW facilities are regulated to ensure that risks to the environment are prevented or minimised.

The regulatory process requires an applicant to submit a detailed application, setting out in particular the controls on environmental pollution emitted to all media. The application will include an assessment of the environmental and health effects of these emissions. This application will be carefully reviewed by the regulator, and will be open to consultation with statutory and non-statutory consultees including members of the public. The Environment Agency’s Briefing Note on regulation of EfW facilities confirms that:

Before reaching a decision to grant a permit, we must be satisfied that:

- *the applicant has demonstrated that the proposed facility meets the requirements of the Environmental Permitting Regulations and uses Best Available Techniques in its design and operation. It must also meet criteria set out in other relevant Directives on Air Quality, Urban Waste Water and Dangerous Substance;*
- *the standards proposed for the design, construction and operation of the facility meet or exceed our guidance, national legislation and relevant Directives;*
- *the comments received from the public and statutory consultees have been taken into account;*
- *as far as practicable, the energy generated by the EfW plant will be recovered for use;*
- *the amount of residues and their harmfulness will be minimised and recycled where appropriate; and*
- *proposed measurement techniques for emissions are in line with those specified in national legislation and relevant Directives.*

We will only issue a permit if we are sure that the plant will be designed, constructed and operated in a way that will not significantly pollute the environment or harm human health.

If a permit is issued for a facility, it contains a series of legally binding conditions on the operator of an EfW facility. These conditions cover the plant and equipment, but also address wider issues such as staff training and management, monitoring and record keeping.

Once a facility has been permitted and constructed, the Environment Agency's role is to work with the operator and other local stakeholders to continually assess and monitor the performance of the facility. This role includes reviewing monitoring data, visits and audits of the site, and investigation of any potential pollution incidents (see section 3.8 below).

4 Summary of air quality issues

4.1 Emissions to air from EfW facilities

The emissions of greatest significance from EfW facilities are set out in the Waste Incineration Directive (2000/76/EC). Table 1 below summarises information on the key emissions from UK EfW facilities accepting municipal solid waste (MSW).

Table 1: Emissions to air from EfW and other sources in the UK

Substance	UK total emissions (2009)	UK Energy from Waste emissions (2009)	EfW as percen-tage of UK total	Other important sources
Carbon monoxide	2,340,000 T/year	410 T/year	0.018%	Road traffic: 46%
Volatile organic compounds	930,000 T/year	20 T/year	0.002%	Road traffic: 9% Decorative paints: 4%
Oxides of nitrogen	1,530,000 T/year	3420 T/year	0.224%	Power generation: 16% Road traffic: 24%
Particulate matter (PM_{10})	160,000 T/year	50 T/year	0.031%	Power generation: 4% Road traffic: 30% Domestic: 10%
Methane	2,090,000 T/year	1850 T/year	0.089%	Agriculture: 41% Natural gas leakage: 10%
Sulphur dioxide	580,000 T/year	330 T/year	0.057%	Power generation: 27% Shipping: 34%
Dioxins and furans	202 gITEQ/year	4.8 gITEQ/year	2.4%	Fireworks: 3% Accidental fires & open waste burning: 41% Crematoria: 5% Metal manufacture: 17%
Arsenic	13.6 T/year	0.03 T/year	0.22%	Power generation: 6% Domestic: 4%
Cadmium	3.0 T/year	0.05 T/year	1.7%	Metal manufacture: 33%

(Adapted from National Atmospheric Emissions Inventory (2012) Emissions analysed by UNECE Source Category)

Table 2 shows some of the emissions from an EfW plant accepting around 275,000 tonnes per year of MSW, similar to the size of a proposed EfW facility in London Borough of Sutton. The table also shows a comparison source which would result in a similar amount of emissions of each substance.

Table 5: Emissions from an EfW plant accepting 275,000 tonnes per year of MSW

Substance	Annual emissions to air from EfW facility	Approximately equivalent to
Carbon monoxide	16500 kg/year	A 1 km stretch of a typical motorway
Volatile organic compounds	2200 kg/year	A 0.7 km stretch of a typical motorway
Oxides of nitrogen	440000 kg/year	An 18 km stretch of a typical motorway
Particulate matter (PM_{10})	10500 kg/year	A 13 km stretch of a typical motorway
Methane	5200 kg/year	A herd of 100 cows
Sulphur dioxide	11600 kg/year	75 return cross-channel ferry journeys (or 2 days sailings at peak times)
Dioxins and furans	0.11 g/year	Accidental fires in the London Borough of Sutton
Arsenic	1.4 kg/year	About one fortieth of the emissions from a medium sized UK coal-fired power station
Cadmium	1.4 kg/year	A medium sized UK coal-fired power station

(Adapted from Defra (2004) with supporting data from Department for Transport (2011), Highways Agency (2007), IPCC (2000), NAEI (2012), and Environment Agency (2012))

4.2 Emissions Monitoring

EfW facilities are fitted with process and emissions monitoring equipment. Continuous monitoring is carried out of a wide range of emissions, including substances of concern with regard to potential effects on health such as oxides of nitrogen and particulate matter.

Other substances such as dioxins and furans and metals cannot be measured continuously. Emissions to air of these substances are controlled by ensuring good combustion conditions in the process together with well designed and operated air pollution control. The presence of low levels of substances such as carbon monoxide and volatile organic compounds in emissions to air is indicative of good combustion conditions. The levels of dioxins and furans and metals in emissions are measured periodically (typically two or four times per year) to ensure that the expected performance is being maintained.

The results of continuous monitoring and periodic check monitoring must be reported to the Environment Agency. Monitoring results reported to the Environment Agency are made available to the public via the public register. At some facilities, continuous monitoring data are made available via a website (e.g. see http://www.sita.co.im/our-facility/emissions or http://www.selchp.com/emissions.asp).

4.3 Key issues

The emissions to air of potential concern with regard to EfW facilities are as follows:

- Nanoparticles/ultrafine particles
- Dioxins and furans
- Trace metals
- Nitrogen dioxide
- Emissions during abnormal operating conditions

The Council has also asked to be advised on the links between emissions to air, compliance with air quality standards and objectives, and the risk of health effects. This is discussed in Chapter 4 below.

The remaining issues are addressed in the following sections.

4.4 Nanoparticles/ultrafine particles

4.4.1 Total particulate matter

Emissions of particulate matter from modern EfW facilities are limited under the provisions of the Waste Incineration Directive. The emission limit applicable to particulate matter emissions is 10 milligrams per normalised cubic metre (mg/Nm^3). Most facilities are equipped with bag filters, and emissions are typically 1-2 mg/Nm^3. This typically results in a slight contribution from a waste incineration facility to environmental levels of particulate matter, and this contribution would not be significant in terms of potential environmental or health effects in the local area. In a national context, the contribution from EfW facilities to levels of particulate matter is even less than in the local context, with MSW incineration giving rise to 0.042% of UK emissions of fine particles (referred to as "$PM_{2.5}$") in 2009 (NAEI, 2012). More significant sources include road traffic (29% of UK total), residential combustion (14%) and electricity generation (5.5%)

4.4.2 Nanoparticles

Section 4.4.1 addresses mainly the larger fractions of airborne particulate matter. It may be the much smaller particles ("ultrafine" or "nano" particles – that is, particles with a diameter of 0.1 microns or less) which are of concern with regard to their effects on health. It is also plausible that the risks to health associated with particulate matter are more closely linked to the number of particles, rather than the mass of particles.

As with other sources of airborne nanoparticles, there is limited data on emissions of nanoparticles from EfW facilities. Recently published research describes measurements of particulate matter emitted from a waste to energy incinerator in Piacenza, Italy (Buonanno et al. 2009). The study found that no particles with aerodynamic diameters greater than 2.5 µm were present in emissions to air. 65% of the measured $PM_{2.5}$ mass was from sub-micrometre particles (PM_1) and the contribution of $PM_{0.1}$ to the mass of particulates was negligible. Most of the mass was from particles that were between 0.1 and 1 microns in aerodynamic diameter. The numbers of particles were distributed approximately equally between particles greater than and less than 0.1 micron.

These findings indicate that EfW facilities would be expected to make a small contribution to environmental levels of ultrafine particles, similarly to the position in relation to larger particles.

This was indeed found to be the case in a subsequent environmental monitoring survey of particle number and size distribution (Buonanno et al., 2010). Levels of particulate matter in the air close to a waste incinerator were found to be low in the Italian context. An analysis of the elemental composition of particulates indicated that sources other than the EfW facility accounted for all the elements present, and the contribution from the EfW facility was not detectable.

In a separate study of fine and ultrafine particles on the surface of foodstuffs in Italy, the authors concluded that "*little evidence is found for particles whose origin could be attributed to industrial combustion processes, such as waste incineration*" (Giordano et al., 2011). Similarly, Morishita et al. (2011a and 2011b) found that waste incineration facilities made a minimal contribution to $PM_{2.5}$ levels in urban environments in the United States. These findings are consistent with a minimal and non-detectable contribution of waste incineration to environmental levels of ultrafine particulate matter. More significant sources included road traffic, industrial sources and secondary particulates.

4.5 Dioxins and furans

Emissions to air of dioxins and furans from modern MSW incineration facilities are substantially less than those emitted from incineration facilities in the past. This has

stemmed from the introduction of a demanding emission standard under the Waste Incineration Directive which has led in turn to substantial reductions in emissions of dioxins and furans through improved design and operation of emission control techniques.

These changes mean that MSW incineration is now no longer a significant source of emissions to air of dioxins and furans. This is illustrated in Figure 1.

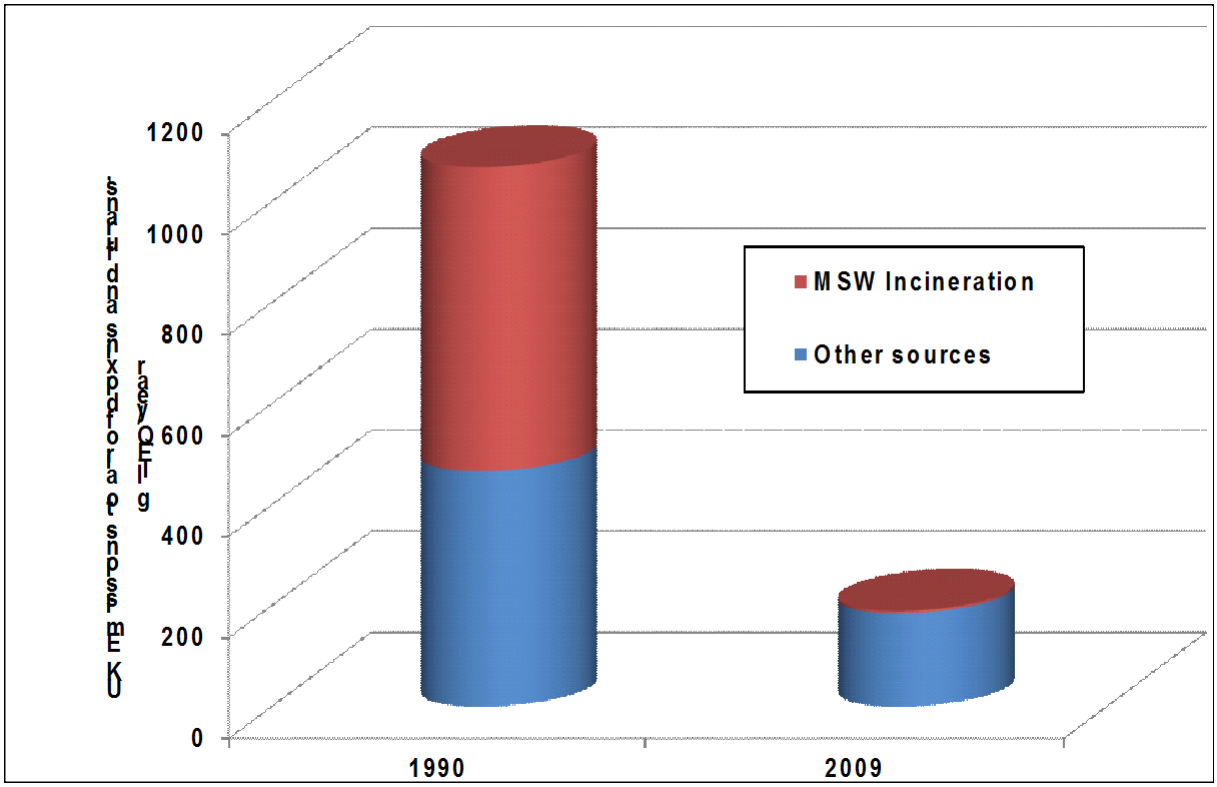

Figure 1: Emissions to air of dioxins and furans from the UK (NAEI, 2012)

In a national context, EfW facilities now account for approximately 2.5% of UK emissions to air of dioxins and furans, and have reduced by over 99% since 1990. More important sources in 2009 included accidental fires and open burning of waste, agricultural straw burning, the iron and steel manufacturing industry, and crematoria.

In a local context, it remains important to ensure that emissions to air of dioxins and furans from EfW facilities do not have significant environmental and health effects. This is normally carried out using exposure assessment techniques. Because of the minimal emissions of dioxins and furans from current EfW facilities, it can normally be demonstrated that any individual facility will have no significant adverse effects on health or the local environment.

Recent surveys by De Felip et al. (2008), Ingelido et al. (2008) and Reis et al. (2007a and 2007b) found no detectable effect of EfW emissions on levels of dioxins and furans in people living near EfW facilities. These findings are consistent with a slight and insignificant contribution to exposure to dioxins and furans from the incinerator facilities.

4.6 Trace metals

In preparing a planning or permit application for an EfW facility, it is normal practice to use an air quality modelling system to forecast levels of released substances in the atmosphere in the vicinity of the proposed facility. This assessment is carried out for a range of substances, including those listed in the Waste Incineration Directive. The forecast levels of released substances are assessed against standards and guidelines for acceptable levels of air quality, which are set by bodies such as the World Health Organisation, the European

Commission, the UK Expert Panel on Air Quality Standards and the UK Environment Agency.

Experience of EfW facilities in the UK is that modelled levels of trace metals are often present at the highest levels relative to the applicable air quality standards and guidelines. This means that particular attention has to be paid to the assessment of trace metals, and to ensuring that the facility design provides appropriate protection for local air quality. It would be unusual for an EfW facility to be located in an area where levels of trace metals are above the relevant standards – this would need special attention and scrutiny during the planning and permitting process. No facility would be designed on the basis that it would result in levels of metals exceeding the relevant air quality standards.

On this basis, it is concluded that EfW facilities can be designed to comply with air quality standards and guidelines for trace metals. However, careful attention must be paid to this issue to ensure that the design of a new facility is appropriate.

4.7 Oxides of nitrogen

As described in Section 4.6, air quality modelling systems are used to forecast levels of released substances in the atmosphere in the vicinity of a proposed EfW facility. As for trace metals, levels of oxides of nitrogen can be among the substances forecast to be present at the highest levels relative to the applicable air quality standards and guidelines.

At the same time, in some urban areas, background levels of nitrogen dioxide approach or exceed the air quality standards. Such areas would normally be designated as “Air Quality Management Areas.” This means that the design of any proposed EfW facility which could affect an area of high background levels of nitrogen dioxide would need to take account of these background levels. Typically, this would mean ensuring that the proposed facility would contribute no more than 1% of the air quality standard to background levels of nitrogen dioxide. This can be a critical influence on the design of EfW facilities in some urban areas, and would need special attention and scrutiny during the planning and permitting process. As for metals, no facility would be designed on the basis that it would of itself result in levels of nitrogen dioxide exceeding the relevant air quality standards.

On this basis, it is concluded that EfW facilities can be designed to comply with the air quality standards for nitrogen dioxide. Careful attention must be paid to nitrogen dioxide in sensitive areas, to ensure that the design of a new facility is appropriate.

4.8 Abnormal operating conditions

As with any industrial facility, EfW facilities can be subject to occasional operational difficulties resulting in abnormal operating conditions and potentially increased emissions. Shut-down and start-up processes can also potentially result in higher emissions than normal operations. A measurement study carried out for the Environment Agency (2008) found emissions of dioxins and furans were increased during shutdown and start-up phases, but the mass of dioxin emitted during shutdown and start-up for a four day planned outage was similar to the emission which would have occurred during normal operation in the same period.

EfW facilities are fitted with process and emissions monitoring equipment. Continuous monitoring is carried out for a wide range of emissions, including substances of concern with regard to potential effects on health such as oxides of nitrogen and particulate matter. Other substances such as dioxins and furans and metals cannot be measured continuously. Emissions to air of these substances are controlled by ensuring good combustion conditions in the process together with well designed and operated air pollution control systems. The presence of low levels of substances such as carbon monoxide and volatile organic compounds in emissions to air is indicative of good combustion conditions. The levels of

dioxins and furans and metals in emissions are measured periodically (typically two or four times per year) to ensure that the expected performance is being maintained.

Nevertheless, foreseeable abnormal operating conditions need to be taken into account in studies using forecasting or modelling techniques to predict the health risks associated with EfW facilities. Consideration of abnormal operating conditions is a requirement of the planning and permitting process in the UK.

If an emissions limit is exceeded during operation, the Environment Agency must be notified within 24 hours. This is followed by a more detailed report into the incident, including an assessment of the environmental impact and the steps proposed to avoid a recurrence of the incident. Such incidents do not normally have any significant adverse environmental consequences (Defra, 2004). The Environment Agency will decide whether any enforcement action is needed, and/or whether the operator should be prosecuted, depending on the seriousness of any breach.

5 Summary of health issues

5.1 Key issues

The key issues which give rise to plausible concern with regard to EfW facilities are as follows:

- Infant mortality
- Other adverse birth outcomes
- Carcinogens and cancer risk

The Council has also asked to be advised on the links between emissions to air, compliance with air quality standards and objectives, and the risk of health effects.

5.2 Other reviews

The risks to health posed by EfW facilities have been studied for many years. These studies have recently been reviewed by bodies including the Committee on Carcinogenicity, the Health Protection Agency and Health Protection Scotland/SEPA.

The Health Protection Agency (2010) concluded that "*Modern, well managed incinerators make only a small contribution to local concentrations of air pollutants. It is possible that such small additions could have an impact on health but such effects, if they exist, are likely to be very small and not detectable.*"

Health Protection Scotland/SEPA (2009) carried out a detailed literature review, and found that drawing an overall conclusion on the health effects of incineration in total is difficult. The body of evidence was found to be inconsistent and inconclusive. HPS/SEPA found that there may have been an association between emissions from waste incinerators in the past and some forms of cancer. HPS concluded that any past effects were small, and current effects should be lower still.

The HPS/SEPA review highlighted concerns that the quantity of waste incinerated could increase in the future, which could have the potential to result in an increased health burden. In view of these concerns and the limitations of health effect studies described above, HPS/SEPA concluded that a precautionary approach should continue to be taken by the regulatory and planning authorities. HPS/SEPA found that current planning/permitting measures were adequate for the control of health effects, and there was no need to introduce further controls.

The Committee on Carcinogenicity (2009) also found some evidence of an association between residence near to incineration and the incidence of less common cancers in the past. The Committee concluded that this finding could not be extended to current incinerators in view of the lower emissions. A similar view was reached by the Associazione Italiana di Epidemiologia (2008)

In overall terms, these reviews indicate that there may have been effects on health due to the operation of waste incineration plant in the past. In view of the substantial reductions in emissions from EfW facilities in the past two decades, any effects associated with facilities operated to current standards are likely to be very small and not detectable. However, the health issues that may have occurred in the past indicate the importance of controls on emissions, ensuring that the limits set by the Waste Incineration Directive are met, and thereby ensuring that the potential health issues do not arise

5.3 Carcinogens and cancer risk

5.3.1 Overview

In common with many other activities, EfW facilities are responsible for emissions of substances which are known or suspected carcinogens. The substances of concern include dioxins and furans, polycyclic aromatic hydrocarbons and some metals. These substances were emitted at much higher levels from older plant operating prior to the implementation of the Waste Incineration Directive. Exposure to these substances results in increased risk of cancers for the exposed population.

A wide range of studies has been carried out to investigate the significance of these risks. Studies of these health risks are subject to difficulties for reasons which include the following:

- There may be a period of years or decades between exposure and the occurrence of cancer (known as "latency"). This may make detection and attribution of any association to a hazardous environmental exposure particularly difficult.
- There are particular problems when rare health outcomes are studied, due to the difficulty of interpreting variation in small numbers of cases and the risks of false identification of clusters due to random variation.
- It is difficult to establish the exposure of groups potentially affected by emissions from EfW facilities. Distance from a facility is often used as a surrogate for exposure to emissions. In practice, exposure may have been variable or intermittent, and affected by factors such as weather patterns and availability of locally sourced foods.
- There are likely to be other sources of the substances of concern which could affect the population under consideration, as well as other factors such as diet and lifestyle which need to be taken into account.

These factors make it harder to identify any effects which may be associated with emissions of carcinogenic substances to the environment.

The expert reviews summarised in Section 5.2 are consistent in concluding that there may have been a detectable increase in cancer risk associated with exposure to emissions from waste incineration facilities in the past. These reviews are also consistent in finding that there is no evidence of an increased risk of cancer associated with EfW facilities operated to current UK and European standards. Similarly, Reis (2011) concluded:

> "*a significant exposure of local populations to the most concern-raising pollutants from incineration processes is becoming ever more unlikely.*"

Some recent studies provide a consistent picture. Recent work carried out by Federico et al. (2010) and Gouveia & Prado (2010) found no increased risk of cancer associated with exposure to emissions from EfW facilities in Italy and Brazil.

5.3.2 Studies of facilities with higher emissions than current UK facilities

A number of recent studies have reported an association between cancer incidence and exposure to emissions from incinerator facilities, which at face value is of potential concern. A number of these studies relate to facilities emitting substantially higher quantities of dioxins and furans and other pollutants than would be permitted in the UK (Comba et al., 2003; Floret et al., 2003; Tango et al., 2004; Viel et al., 2008; Zambon et al., 2007). This is because of the age, geographical location, and/or operating regime at the facilities. For example, Tango et al. (2004) studied waste incinerators in Japan with emissions more than 800 times the emission limit set in the Waste Incineration Directive. Similarly, the rate of emissions of dioxins and furans from industrial sources in the Venice area estimated by Zambon et al (2007) was more than ten times higher than the emissions of dioxins and furans from all MSW incineration facilities in the UK in 2009.

Consequently, the associations identified in these studies suggest that current facilities operating in the UK would have no detectable effects on cancer incidence in local

populations. Furthermore, the studies of Comba et al. (2003) and Zambon et al. (2007) reflected exposure to a wide range of industrial sources, and were not limited to waste incineration facilities.

5.3.3 Strength of association

The World Cancer Research Foundation and American Institute for Cancer Research (1997) adopted a simple framework for evaluation of epidemiological studies. This allows associations identified in epidemiological studies to be classified as Strong, Moderate, Weak or No association.

Following this framework, only the association found by Zambon et al. (2007) would rank as "Moderate" – all other studies would be described as "weak" or "no association". As discussed above, the study of Zambon et al. (2007) relates to a wider range of sources of environmental emissions, and to much greater emissions of dioxins and furans.

5.3.4 Conclusion

In view of these considerations, and taking account of the uncertainty inherent in studies of this nature, it is concluded that EfW facilities as currently operated in the UK are most unlikely to have any significant or detectable effects on cancer incidence.

5.4 Infant mortality

Studies of the rates of infant mortality in wards surrounding EfW facilities have been made available (e.g. UKHR, 2009). These maps are interpreted to suggest that the rates of infant mortality are higher downwind of EfW facilities and lower upwind of EfW facilities. It is then suggested that the EfW facilities are the cause of the apparent increase in infant mortality.

These studies are flawed for a number of reasons.

1. In the cases which have been evaluated, there is in fact no clear pattern of higher rates in wards downwind (north-east) of the facility and lower rates upwind (south-west) of the facility. The actual pattern is more complex, and appears to be more closely aligned to aspects such as other sources of environmental pollution, or housing density. Further evaluation would be needed to draw definitive conclusions about these apparent correlations.
2. Similar patterns of infant mortality are observed in areas with no EfW facility.
3. If emissions from the EfW facilities were a significant factor in determining the rates of infant mortality, the pattern would not be as simple as a higher rate downwind of the facility and a lower rate upwind of the facility. Because the wind blows from all directions for some parts of the year, emissions from an EfW facility in the UK would typically affect areas to the north-east to the greatest extent, areas to the south-west to some extent, and areas to the north-west and south-east to a lesser extent. This pattern is also not reflected in the cases which have been evaluated.

It is concluded that claims of the effects of EfW facilities on infant mortality made on the basis of mapping studies of this nature should not be considered a matter of concern.

However, because of the profile given to this issue in recent years, AEA understands that the Health Protection Agency has proposed to carry out a study of infant mortality and other health issues in relation to waste incineration facilities.

5.5 Other adverse birth outcomes

A number of studies have investigated the potential effects of emissions from EfW facilities on adverse birth outcomes such as congenital abnormalities. The weight of evidence is that there is generally no detectable association between exposure to emissions from EfW

facilities and birth outcomes, particularly when considering facilities operating to current European standards.

Tango et al. (2004) identified associations between dioxin exposure and risk of infant death. As described above, this study focused on facilities emitting dioxins and furans at levels 800 times higher than would be permitted in the UK. Cordier et al (2004 and 2010) found increased risks for renal dysplasia, facial cleft and urinary tract birth defects in France associated with past emissions from MSW incinerators at a time when emissions of dioxins and furans and other substances were at much higher levels than presently permitted. The findings of these studies were also complicated by a possible association with traffic emissions.

Vinceti et al. (2008) studied population exposure to emissions from an incinerator in Modena between 2003 and 2006. This study found no association between the incidence of adverse outcomes and maternal residence relative to the incinerator.

Lin et al. (2006) studied birth outcomes in populations living close to an EfW facility in Taiwan in 1997. The dioxin exposure levels under consideration were a factor of 10 or more higher than would be expected in relation to current UK EfW facilities. It was concluded that "*the incinerator generated dioxin poses little effects on birth weight and female birth, but might pose small effects on gestational age.*"

On the balance of evidence, and taking account of the uncertainty inherent in studies of this nature, it is concluded that EfW facilities as currently operated in the UK are most unlikely to have any significant or detectable effects on the incidence of adverse birth outcomes.

5.6 Air quality standards and guidelines

The Local Authority has a duty to assess air quality in its borough, and ensure that air quality standards for the following substances are achieved at relevant locations:

- Benzene
- 1,3 butadiene
- Carbon monoxide
- Lead
- Nitrogen dioxide
- Particles (PM_{10})
- Sulphur dioxide

Progress towards achieving these standards in the London Borough of Sutton is reported by the Council via its website (http://www.sutton.gov.uk/index.aspx?articleid=11374). In Sutton, all air quality standards are forecast to be achieved with the exception of the standard for annual mean nitrogen dioxide and PM_{10} levels at some locations close to main roads (London Borough of Sutton, 2008 and 2009).

Other air quality standards and guidelines are set by bodies including the European Commission (Directive 2008/50/EC and the fourth air quality daughter directive 2004/107/EC), the World Health Organisation (WHO, 2000), the Expert Panel on Air Quality Standards (EPAQS, 2009) and the Environment Agency (2010). These air quality standards and guidelines are generally specified on the basis of the protection of human health based on current scientific understanding, and a significant margin of safety is normally built into the standards. This means that air quality in compliance with these standards and guidelines would not be expected to have any significant adverse effects on health.

In the design of an EfW facility, a developer needs to ensure that the proposed facility does not result in air quality standards or guidelines being exceeded. This requires the developer to assess existing air quality in the area, and to forecast the additional impact which could result from the proposed facility together with other relevant permitted development.

- In situations where baseline air quality complies with the relevant standards and guidelines, a new facility should not result in an exceedance of the relevant standard/guideline, and should generally contribute a small fraction of the standard/guideline.
- In situations where baseline air quality does not comply with the relevant standards and guidelines, a new facility should make an insignificant contribution to the standard/guideline. This is typically interpreted to mean a contribution of less than 1% to baseline levels of the substances of concern.

Complying with these approaches means that an EfW facility would not have a significant adverse effect on local air quality. While a new development would increase levels of air pollutants in the local area, it should not materially affect the ability of a local authority to fulfil its obligations in relation to air quality.

Furthermore, complying with these approaches means that emissions to air from an EfW facility would not significantly affect the health of people living and working in the local area.

6 Conclusions

Emissions to air from incineration of municipal waste in the UK gives rise to minor contributions to levels of air pollutants. A facility of the scale proposed for the London Borough of Sutton would result in emissions to air which are comparable with many familiar sources. For example, emissions of dioxins and furans from the proposed facility would be expected to be similar to emissions from accidental fires in the borough, although emissions from an EfW facility would be subject to much better control and would result in much lower public exposure.

On the basis of the discussion in Sections 3 and 4, it is concluded that emissions from current EfW facilities in the UK would not be expected to give rise to any significant or detectable effects on air quality or health. Emissions from EfW facilities as currently operated in the UK are substantially lower than those from facilities operating prior to the implementation of the Waste Incineration Directive.

Taking account of the uncertainty inherent in epidemiological studies of EfW facilities, it is concluded that EfW facilities as currently operated in the UK are most unlikely to have any significant or detectable effects on cancer incidence, the incidence of adverse birth outcomes, or the incidence of respiratory disease.

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