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REPUBLIC OF SOUTH AFRICA

NATIONAL POLICY ON HIGH TEMPERATURE THERMAL WASTE TREATMENT AND CEMENT KILN ALTERNATIVE FUEL USE

LITERATURE REVIEW ON HIGH TEMPERATURE THERMAL TREATMENT OF HAZARDOUS WASTE

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Hazardous Waste Management

High temperature thermal treatment of hazardous waste - a literature review

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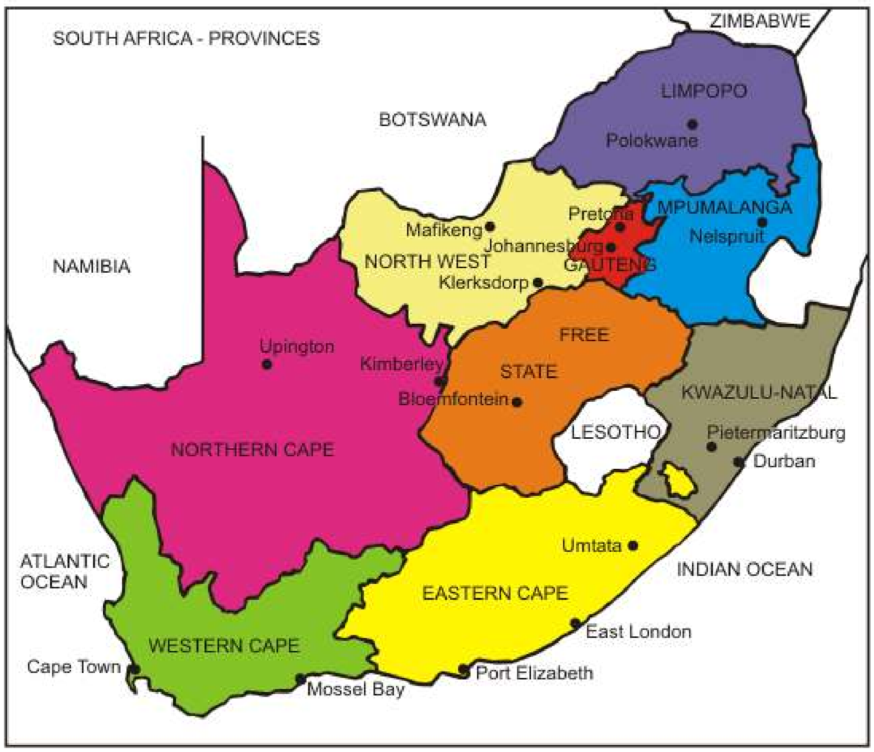


Figure 1 South Africa - Provinces

II List of abbreviations

Abbreviation	Explanation
ADR	International Agreement regarding the Transport of Dangerous Goods by Road
APC	Air Pollution Control (residues)
BAT	Best Available Techniques
BEP	Best Environmental Practice
BHF	Bag House Filters
BREF	BAT Reference Document
CEMs	Continuous emission monitors
CHP	Combined Heat and Power
CEWEP	Confederation of European Waste-to-Energy Plants
DE	Destruction Efficiency
DEAT	The Department of Environmental Affairs and Tourism
DRE	Destruction and Removal Efficiency
Dscf	Dry standard cubic foot (1 dscf = 0.02832 dscm)
Dscm	Dry standard cubic meter
e-CFR	Electronic Code of Federal Regulations
EEA	The European Economic Association
ELV	End of Life Vehicles
ESM	Environmental Sound Management
ESP	Electrostatic Precipitator
FGT	Flue Gas Treatment (Techniques)
HWM	Hazardous Waste Management
IPPC	Integrated Pollution Prevention Control
I-TEQ	International Toxicity equivalents (for dioxins)
IUPAC	International Union of Pure and Applied Chemistry
LGU	Local Government Units
MSW	Municipal Solid Waste
NGO	Non Governmental Organisation
OECD	Organisation for Economic Co-operation and Development:
PAH	Poly Aromatic Hydrocarbons
PCB	Poly Chlorinated Biphenyls
PCT	Poly Chlorinated Terphenyls
PCDD/F	Poly Chlorinated Dibenzo-p-dioxins/ Furans
PIC	Products of incomplete combustion

POHC	Principal organic hazardous constituent
POP	Persistent Organic Pollutants
RSA	Republic of South Africa
TLCP	Toxicity Leaching Characteristic Procedure
TOC	Total Organic Carbon
TWG	Technical work group (making BATs in EU)
VOC	Volatile Organic Carbons
WEEE	Waste Electrical and Electronic Equipment
WID	Waste Incineration Directive
WTE	Waste to Energy

1 Executive Summary

The present review constitutes one of several outputs of a project under the Danish – South African Urban Environment Programme to assist the Department of Environmental Affairs and Tourism in all aspects required to

- develop a policy statement on the destruction of hazardous waste through high temperature thermal treatment,
- develop a specific policy on the use of selected hazardous and general waste in cement kilns as a fuel replacement,
- and to develop guidelines and management requirements to support such a policy.

This review is focusing on international best practice with respect to high temperature incineration of hazardous waste while a sister report, prepared by Dr. Kaare Karstensen, reviews the best practice of the use of cement kilns for hazardous waste destruction and the use of waste as alternative energy source in cement kilns.

The reviews are further supplemented by a report with a comparative assessment of the hazardous waste profile found in South Africa to that found in countries where alternative fuels are utilised in cement kilns and a Hazardous Waste Incineration Guideline hereunder criteria for emission monitoring

Specific objectives
The specific objective of this literature review is to provide an overview of:

- International legislation on incineration;
- Relevant international policies and strategies associated with incineration;
- International best practice for hazardous waste management;
- Relevant technologies used internationally for the disposal/destruction of selected high calorific value wastes;
- Relevant emission standards and guidelines associated with the incineration of hazardous waste.

Hazardous waste incineration vs. municipal solid waste incineration
When discussing the application of high temperature incineration for waste destruction it is essential to distinguish between incineration of hazardous waste and incineration of municipal solid waste. By the incineration of hazardous waste the main objective is the destruction of hazardous substances and prevents human exposure to the substances and the release of the substances into the environment.

By incineration of municipal solid waste the main objectives are the reduction of the waste volume, destruction of infectious materials and the utilisation of the energy content of the waste. When considering the advantages and drawbacks of the use of incineration techniques it is thus also essential to distinguish between the different waste types. The present review does not go into detail with the advantages and drawbacks of incineration as disposal method for municipal solid waste. However, the review of the relevant incineration technologies also includes technologies for municipal solid waste incineration.

Landfilling of waste without prior treatment is today globally the most widespread disposal method for municipal solid waste (which is not otherwise recovered) and in many developed countries it is still considered as an acceptable disposal method provided that the landfills are managed properly.

Contrary to this it is in general, internationally recognised that hazardous waste should be treated specifically. For combustible hazardous waste e.g. used solvents not being recovered, incineration does provide a generally accepted disposal route as reflected in guidelines from international organisations. Guidelines for the environmentally sound incineration of hazardous waste has been prepared by a number of international organisations including the Basel Convention Secretariat, UNEP Chemicals and the European Union, and form basis for a part of this review.

Hazardous waste suitable for incineration

Only older inventories from 1992 and 1997 of the generation of hazardous waste by type in RSA exist. Based on the available information it is estimated that in 1997 about 160,000 tons of organic hazardous waste suitable for incineration is annually generated in the RFA. An updated estimation of the amount of organic hazardous waste is being made in the "South African Waste Profile Report".

The preliminary estimations of the amounts are, based on the experience from other countries, considered sufficient to justify the construction of a hazardous waste incineration plant in case this disposal method is selected for use in RSA. The figures must, however, be estimated more correctly through a detailed national inventory on hazardous waste if a dedicated hazardous waste incineration plant is to be implemented. Concerning the treatment of hazardous waste in cement kilns as AFR's, the situation is different. The waste treatment in the cement kiln solution is not driven by law, but by economy, and the cement kilns do not secure that all hazardous waste is treated. Therefore the cement kiln solution does not necessarily need the knowledge of the total amount of hazardous waste.

By the estimation of the potential quantities for incineration it is necessary simultaneously to assess the potential and options for avoiding the generation of the hazardous waste as well as alternative disposal options at a higher level of the waste hierarchy: reuse as raw material and preparation and volume reduction.

The experience from developed countries is that, in spite of waste minimization efforts and increased recycling, significant volumes of combustible waste is generated by a number of industrial processes and domestic use of chemicals.

For those combustible hazardous wastes that cannot be reused, incineration has proven to be an environmentally sound disposal method provided that best available techniques (BAT) and best environmental practice (BEP) are applied.

Another critical aspect in terms of the commercial viability of dedicated hazardous waste treatment plant is the availability of effective enforcement measures to control the flow of waste to the facilities and government's willingness to make use of such enforcement tools, concessions etc..

BAT for Hazardous Waste Incineration

In order to reduce the environmental and health impacts, historically associated with incineration of waste, it is necessary to undertake the incineration under a certain operational regime as concern temperature, retention time, turbulence, and other process parameters. The report reviews the process parameters considered as BAT for incineration of hazardous and municipal solid waste. With application of BAT, the flue gas can nowadays be cleaned to a level considered acceptable within international agreements on reduction of atmospheric pollution like the Convention on Long-Range Transboundary Air Pollution under UNECE or the Stockholm Convention. The wastewater (if any, depending on the technology) can be cleaned to a level where the pollution from the incineration in general is not considered an issue of concern.

The application of BAT should be combined with Best Environmental Practice (BEP) to reduce the effects of accidents and releases during un-normal operation e.g. by start-up and shut-down. Application of BAT and BEP requires among other proper process monitoring and the presence of adequately trained personnel. The Hazardous Waste Guidelines report review shortly procedures that should be in place to reduce the risks associated with accidents and un-normal operation to an acceptable level.

Emission of pollutants

The generation and release of unintentionally produced POPs (in particular dioxins and furans) has been, and still is, a major concern in relation to the application of incineration for hazardous waste disposal.

Today, BAT implies the use of techniques for specifically reducing the content of PCDD/F (and other POPs) and mercury. The addition of activated carbon to the flue gas is the most applied method. Today an emission limit of 0.1 ng TEQ/Nm^3 or lower is considered an acceptable and reachable level.

By the application of BAT the emission of PCDD/F (and other POPs) has been reduced drastically in countries with extensive use of incineration. As an example, in Germany the total PCDD/F emission from waste incineration decreased from 400 g TEQ (toxicity equivalents) in 1990 to 0.5 g TEQ in 2000 despite the amount of waste incinerated increased. Both in Germany and Denmark, where the major part of the not-recovered hazardous waste and municipal solid waste is incinerated, other PCDD/F sources are today more dominating, by way of example is the total emission from domestic burning in wood stoves larger than the total emission from the incinerators.

When considering the generation of POPs by the incineration is should also be considered to what extent POPs may be generated by other disposal methods. Uncontrolled burning, e.g. by landfill fires, of even a small part of the waste may easily result in higher atmospheric emission than the emission from incineration of the waste.

Generation of residues

With the application of air pollution controls most pollutants present in the raw flue gas is transferred to residues from the flue gas process. By the treatment, lime for acid gases removal and activated carbon for PCDD/F and mercury removal is added to the flue gas. The added ancillary materials constitute a significant part of the produced residues from flue gas treatment.

The amount of heavy metals in the flue gas residues may be reduced by proper waste separation and phasing out of the use of the heavy metals in processes and products giving rise to hazardous waste. Countries in Europe with extensive use of incineration for waste disposal, e.g. Denmark, has notably been on the forefront in the phasing out of the use of heavy metals and the separate collection of waste fractions containing heavy metals like mercury, cadmium and lead.

The amounts of PCDD/F and other POPs in the residues can be reduced by the application of quenchers, which reduce the amount of POPs generated within the flue gas, by catalytic reduction of the substances or by recycling of the activated carbon into the incinerator whereby the PCDD/F captured by the carbon is destructed. The review shortly present options for reducing the amount of PCDD/F in the residues.

Landfilling of residues from flue gas cleaning constitutes a problem as heavy metals, POPs and other pollutants may be leached from the residues. In the EU flue gas cleaning residues from incineration, due to the presence of POPs, in general have to be permanent stored in safe, deep, underground, hard rock formations, salt mines or in a landfill site for hazardous waste (provided that the waste is solidified or partly stabilised where technically feasible). By the possible planning of the application of incineration of hazardous waste in RSA, consideration should be given to the options for final disposal of the residues. It should, however, be noted that the issue of disposal of residues generated from incineration of relatively small volumes of combustible hazardous waste is small compared to the situation when millions of tons of municipal waste are incinerated in a country.

Economics of hazardous waste incineration

The cost of the incineration of hazardous waste depends of the waste volumes to be incinerated and the waste types. Indicative prices for destruction of hazardous waste by incinerations are as follows:

- High heating value liquids: USD 20-150 per tonne
- Medium healing value liquids, sludge's and solids: USD 250-500 per tonne
- High-halogen solids and liquids: USD 1,000-1,500 per tonne

Experience from Nigeria and Angola in small incinerators is that the hazardous waste can be treated at a cost of approximately USD 250-500 per tonne.

To these direct costs may be added some socioeconomic costs related to the environmental and heath impacts associated with releases of pollutants from the incineration. The review present the methodology applied for estimating the associated environmental costs of treatment of non-hazardous waste in Europe, but data specifically comparing the costs of different hazardous waste treatment methods have not been available.

Electricity production and use of the produced heat may improve both the economy and the environmental performance of the incineration process. Experience from Denmark shows that incineration of 150.000 t waste at the hazardous waste plant Kommunekemi in 2006 generated net 19,000 MWh electricity supplied to the grid and 150,000 MWh heat supplied to the local district heating system. By the eventual location of the incinerator in RSA it should be considered whether the heat produced by the incinerator could be utilised e.g. as process heat for industrial processes or for cooling - as supply to the local district heating system is obviously not an option.

When considering the costs of incineration of hazardous waste is should be noted that simply landfilling the hazardous waste without prior treatment cannot be considered an environmentally sound disposal method and is not a sustainable option.

Non-incineration techniques
A number of non-incineration techniques have been developed for destruction of high-chlorinated hazardous substances like PCB and other POPs. Of these techniques Based Catalysed Destruction (BCD) and Gas Phase Catalytic Reduction (GPCR) are the only fully developed techniques. Both techniques are working batch-wise and has until now mainly been applied for destruction of POPs and has apart from de-chlorination of some concentrated and some low-content PCBs not been economically competitive with incineration in the destruction of high-volume hazardous wastes. These techniques are not considered feasible solutions for hazardous waste destruction in general in SA. For particular waste fractions, e.g. liquids with a low PCB content, non-incineration techniques may under certain circumstances be cost-effective options and should be considered.

Application of incineration in South Africa
When compared to other countries, which have invested in hazardous waste incineration, South Africa has the hazardous waste volumes and the waste types justifying the construction of a hazardous waste incineration plant, if this disposal method is selected in RSA. Air emission standards that is much alike European and American standards are already in place, but the need for further regulation e.g. as to the disposal of residues should be investigated.

Investment in incineration facilities is not necessarily incompatible with the application of cement kilns for burning of certain waste types (e.g. tyres, spent pot liners), or the application of non-incineration technologies for some high-chlorinated hazardous waste types.

With the application of BAT and BEP, proper training of the personnel and with proper management and enforcement there is no basis for assuming that the application of hazardous waste incineration in RSA should be less sustainable than application of hazardous waste incineration in the USA, Japan and Europe.

2 Introduction

In the last 30 years increasing problems with hazardous waste have been recognised in most countries worldwide. Hazardous waste is the most toxic part of the general waste problem. Often even small amounts of hazardous waste can be more harmful than big amounts of municipal solid waste. As all POPs are hazardous waste, they are also covered in this description.

Hazardous waste stems normally from industry, producing all kinds of normal very useful products. Everybody is today surrounded by products, which in the production phase have resulted in hazardous waste. From the cloth, spectacles, jewellery etc. we use to the floor, wall, ceiling, kitchen elements, water tap, sink, light bulbs, lamps, windows, pots and pans in our homes. From the bicycles, cars, busses, trains, and aeroplanes to the roads and rails for our transport, to our working places. Everywhere we turn there are valuable products, which in the production phase is likely to generate hazardous waste.

There is no way that modern human beings would return to former time's non-chemical society. Also poor countries are aiming at having the same access to freezers, refrigerators, and other modern industrial products.

Therefore the problem of hazardous waste exists and has to be faced. Through cleaner technology the quantity of hazardous waste can be minimised considerably, but there will always be a rest that needs proper treatment. The conclusion is therefore that all societies must secure the availability of technology for proper hazardous waste treatment. The goal of all hazardous waste technology must be to treat the waste in such a way, that the hazards of the waste are removed, neutralised and/or reduced.

The worst way to treat hazardous waste is to hide the hazardous effect (e.g. by disposing of it untreated in insecure landfills). Furthermore, it must be clear that whatever treatment is given to hazardous waste, residues in terms of rest products, emission gasses and waste waster are produced. Incineration of hazardous waste potentially releases POPs, CO_2, dust, H_2O, acids, heavy metals etc.. Using other techniques than incineration, other residues are produced (e.g. direct landfill produces vapours of organic solvents and risk of groundwater pollution). These facts have to be dealt with in a proper hazardous waste management system /4/.

3 Hazardous Waste Management in South Africa

Over the past years South Africa has developed several waste management policy documents and strategies, including:

- the Integrated Pollution and Waste Management Policy (IP&WM),
- the National Waste Management Strategy,
- the Polokwane Declaration on Waste Management, 2001
- Minimum Requirements for Waste disposal by Landfill, and more recently
- the (draft) Waste Minimisation and Management Bill, that indicate the countries support of managing waste through the waste hierarchy concept.

The Polokwane Declaration on Waste Management of September 2001 set a goal, to "Reduce waste generation and disposal by 50 and 25%, respectively by 2012 and develop a plan for zero waste by 2022". However, not withstanding the significant support for alternative waste management measures found in the waste management policy documents, South Africa has a long tradition of disposing of waste in landfills, both hazardous and municipal solid wastes. This practice will continue into the foreseeable future as very little progress is being made in supporting a move away from landfilling waste. This continued dependency on landfilling of waste is evident in the latest edition of the Minimum Requirements which still focuses on the total load principle which support the dilution and dispersion principle. Similarly the waste classification system used in the country is designed to determine the manner in which waste will react in a landfill.

The landfill emphasis as a waste management option of choice is further strengthened by a number of factors, which include the following:

- The absences of any decisive policy on incineration of waste;
- The absence of any policy on the utilisation of selected hazardous and general wastes as a replacement fuel in combustion processes; and
- The fact that environmental NGOs are apposed to incineration of any waste streams, and have been active in opposing all forms of incineration in the country.
- Higher cost of treatment as opposed to landfill (perceived or not)
- Feasibility in terms of numbers required in a relatively large country like RSA (travel distances)
- Increased operational, management & monitoring costs.

These factors make it extremely difficult to introduce any alternative treatment technologies into RSA or to encourage the use of selected hazardous and general wastes as fuel supplement in any combustion processors. /1/

Based on this the objective of this review is to produce a background on the acceptability or not of high temperature thermal treatment of waste, including hazardous waste. Based on the inception meetings in May 2007 in Pretoria the focus will be on high temperature treatment of hazardous waste. However, also examples from incineration of household waste may be introduced as incineration of waste may be seen as the one and same process. E.g. the EU directive for incineration of waste covers both municipal waste and hazardous waste. The specific objectives of the literature review are:

- International legislation on incineration and the use of alternative fuels as an energy source;
- Relevant international policies and strategies associated with incineration and the use of alternative fuels as an energy source;
- International best practice for hazardous waste management;
- Relevant technologies used internationally for the disposal/destruction of selected high calorific value wastes;
- Relevant emission standards and guidelines associated with the incineration of hazardous waste and the use of alternative fuel as energy source

3.1 Problem Statement

Every year about 1.4 million ton of hazardous waste or more is generated in the republic of South Africa /34/. The largest part of this has an unknown faith, only about 180,000 ton are disposed of at Gautengs H:H sites. In some hazardous waste landfills about 5-7000 tons of hazardous waste is stored every month/35/. It is believed that most of the light organic solvents are evaporating to the air over time, whereas the chlorinated solvents will penetrate the solid waste, and disappear through cracks in the lining when they start to come. Hazardous waste landfills of this kind with untreated chemicals are predicted to become a problem (groundwater, land reuse) for coming generations as well as they right now are adding to the general air pollution in the area.

Another source/81/ states that South Africa currently generates over 47 million m3 of solid waste every year, of which over 5 million m3 is hazardous waste. A survey undertaken as part of the State of the Environment Report (SoER) for South Africa indicated that of the estimated 5 million m3 of hazardous waste generated, only 5% was disposed of at permitted hazardous waste disposal sites, indicating extensive illegal dumping and/or frequent accidents and spillages. In addition, it is predicted that five of the nine provinces will have landfill shortages within the next 10 years (South African SoER, 1999). An only few landfills are permitted as H:H or H:h sites, and therefore suitable for receiving hazardous waste.

At the same time the authorities in the Republic of South Africa are receiving EIA applications associated with proposals to utilise selected hazardous waste types as a substitute energy source for cement kilns. This technology is well-proven and applied in many countries around the world and is approved by the environmental authorities in these countries.

Furthermore, seen in the light of the amount of hazardous waste produced in South Africa there is a general need for treatment plants for hazardous waste and introduction of effective regulatory means of controlling the flow and disposal/treatment of hazardous waste. In the absence of effective means of enforcing proper disposal of hazardous waste treatment plants may not be financially viable.

Disposing of untreated chemicals in landfill is internationally seen as **not** best available technology (BAT). Volatile Organic Carbons (VOCs) must be limited in order to prevent or reduce air pollution resulting from the contribution of VOCs to the formation of tropospheric ozone /62/.Furthermore, proper hazardous waste management is not only good for the environment it is also a business that may be an advantage for the country (see Annex 2).

3.2 Generation of Hazardous Waste in RSA

The generation of organic hazardous waste in South Africa is being estimated in the report "South African Hazardous Waste Profile" that is an output from the present project "National Policy on High Temperature Thermal Waste Treatment and cement Kiln Alternative Fuel Use". In this report the old data from 1997 /109/ has been evaluated and from this it may be estimated that the amount of organic hazardous waste (suitable for high temperature incineration) in South Africa in 1997 was around 160,000 tons.

Results from an attempt to find the disposed amount in 2006 will be reported in the final report.

3.3 Examples from Other Countries

Hazardous Waste Generation in Denmark

The amount of different hazardous waste categories and the treatment of different categories of hazardous waste can be illustrated by the situation in Denmark.

In Denmark (5.3 million inhabitants) the generation of hazardous waste in 2005 is about 340,000 tons /59, 60/. Of this about 104,000 tons (or about 30 %) is incinerated at Kommunekemi (The Central Danish Hazardous Waste Treatment Plant). The combustible parts of the waste consist of spent solvents, waste oils, chemical waste, industrial sewage sludge, medical waste from clinics (only a part of this waste generated in the country) and animal and vegetable waste (highly contaminated waste in this category). The non-combustible amounts of hazardous waste consist mainly of inorganic fractions as neutralised and precipitated filter cakes from spent acids and bases, from flue gas ashes and bottom ashes, from accumulators and batteries, from asbestos waste and from shredder waste where no proper treatment has been developed yet.

Table 1: Amount and categories of hazardous waste generated in Denmark

Hazardous Waste Fractions	Amounts 1999 Tons	Amounts 2005 tons	Treatment
Spent solvents	21,203	31,000	Incineration
Spent acids, bases and brines	13,667	20,000	Neutralised filtered and Landfilled
Waste oils	74,119	36.000	Incineration
Spent chemical catalysts	6,526		Landfill
Chemical waste	24,605	32,000	Incineration
Chemical mother liquer	27.473		Organics are incinerated inorganics are neutralised filtered and landfilled
Industrial sewage sludge	2,355		Incineration
Medical waste from clinics	781	5,000	Incineration
Scrap equipment	832		recycled
Batteries and accumulators	6,587	20,000	recycled
Animal and vegetable waste	3,725		Incineration
Mineral waste	14,338		Landfill
Waste from incineration	13,108	39,000	Landfill
Polluted soil and sludge	819		Landfill
Shredder waste		130,000	Landfill
Asbestos waste		22,000	Landfill
Various		5,000	?
SUM	**210,666**	**340,000**	
Kg/capita	**39.7**	**64.2**	

Hazardous Waste Generation in Malaysia

In Malaysia (18 million inhabitants) hazardous waste is called Scheduled Waste. Malaysia was ready to treat hazardous waste for the first time in 1998.

Based on notification received by the Department of Environment (DOE), a total of 469,584 tonnes of hazardous wastes were produced in 2004. Dross/bottom ash/clinker and oil and hydrocarbon made up the main categories of waste produced in the country.

Of the total wastes generated, 88,268 tonnes (19 %) were treated and disposed of at the Kualiti Alam Treatment & Disposal Facility (hereof it is estimated that about 40 -50,000 tons were incinerated and the rest either treated as inorganic waste or solidified) ; 12,840 tonnes (2.7 %) of clinical wastes were incinerated at licensed off-site facilities; 3,354 tonnes (0.7 %) were exported for recovery purposes; 272,420 tonnes (58 %) of hazardous wastes were recovered at off-site local facilities and an estimated 92,701 tonnes (20 %) were treated and stored on-site at waste generators' premises.

Table 2: Amount and categories of hazardous waste generated in Malysia

Category of waste **(2004**)	Quantity of Waste (T/Year)	Percentage
Photographic	583	0.12
Halogenated Solvents	3,575	0.76
Non Halogenated Solvents	6,729	1.43
Paper and plastic	3,608	0.77
Phenol/Adhesive/Resin	599	0.13
Catalyst	3,963	0.84
Paint/Ink/Dye solvent	5.845	1.24
Paint/Ink/Dye sludge	2,695	0.57
Rubber & Latex	1,884	0.4
Containers	12,449	2.65
Acid/Alkalis	4,279	0.91
Clinical	80,075	17
Oil & hydrocarbon	108,170	23
Mineral Sludge	18,087	3.85
Heavy metal sludge	56,031	11.9
Dross/slag/clinker	147,196	31
Others	13,814	2.9
Total	**469,584**	**100**
Kg/capita	**26.1**	

4 Management of Hazardous Wastes

Managing hazardous waste is a growing concern in many countries. The long term impacts and direct and socio-economic costs of improper disposal can be very high, and the emphasis must be on prevention. A comprehensive management system should include:

1 Policies, legislations, institutions and effective regulations

2 Adequate and acceptable treatment and disposal facilities, either public-private or public-private partnerships /2/.

Improper disposal of hazardous waste is (or was) a huge problem in many countries. Typically, but not ideally, the first stages of pollution control focus on discharges (from poor managed incinerators or no incineration) into air and water, leaving a wide rang of materials, that is poorly controlled. These materials include materials that pose serious threats to public health and the environment and that are considered hazardous under almost any definition. Examples include sludges from chemical plants, clinical wastes, contaminated oils, and metal bearing wastes /2/. These waste streams need to be properly managed.

The road to establishing an effective hazardous waste management (HWM) program is a bumpy one, even in developed industrialised countries. However, in the past thirty years many industrialised countries have established effective hazardous waste management programs. No two countries share identical circumstances in terms of political regime, industrial policy, major industries, geography and the nature of the hazardous waste problem, and therefore different HWM systems are developed.

Fundamentally, the goal of an effective hazardous waste management program is changing the behaviour of those organisations (both public and private) that generate and manage hazardous waste.

The key components of meeting this goal are first - building an effective regulatory program and second - developing adequate treatment, storage and disposal facilities.

Both components present challenges to a country seeking to move from a situation in which there is little or no regulation of hazardous waste to one in which the majority of generators treat, store, and dispose of hazardous waste in an environmentally safe way /3/.

On 9 June 2004, the OECD Council adopted a Recommendation on the Environmentally Sound Management of Waste as can be seen in the "OECD Guidance Manual on Environmentally Sound Management of Waste, 2007" /91/.

The overall purpose of the Council Recommendation envisages enhanced environmentally sound management of waste throughout the OECD area. The

Council Recommendation also states three specific objectives:

1 "sustainable use of natural resources, minimisation of waste and protection of human health and the environment from adverse effects that may result from waste;

2 fair competition between enterprises throughout the OECD area through the implementation of 'core performance elements' (CPEs) by waste management facilities, thus contributing to a level playing field of high environmental standards;

3 through incentives and measures, diversion of waste streams to the extent possible from facilities operating with low standards to facilities that manage waste in an environmentally sound and economically efficient manner;"

The OECD Guidelines mention in the annex that in addition to the EU framework legislation (Waste Framework Directive, 1975 [75/442/EEC as amended], and the Hazardous Waste Directive, 1991 [91/689/EEC as amended]) that sets the foundation for ESM and the IPPC, there is also Directive [96/61/EC] that prescribes BAT, the following Directives implement ESM for specific treatment processes.

European Union legislation on waste management operations
- The Landfill Directive (1999) [1999/31/EC] facilitates and improves the management of landfill sites in an environmentally sound manner by requiring: specific criteria for the location of landfill sites; techniques and engineering to be used in relation to water control; and leachate management, the protection of soil and water and the control of methane emissions. In addition, the Directive proscribes the landfilling of certain wastes, requires the pre-treatment of waste and the classification of sites according to the degree of hazard;

- The Waste Incineration Directive (2000) [2000/76/EC] aims at reducing pollution caused by emissions into the air, soil, surface water and groundwater from incinerators and co-incinerators of hazardous and nonhazardous waste. This is to be achieved through stringent operational conditions and technical requirements and by setting up emission limit values for certain pollutants such as dioxins, heavy metals and acid gases (SO2, NOx and HCl). Residues from the combustion process must be minimised in their amount and harmfulness and recycled where appropriate, and, if not possible, disposed of only under certain conditions.

The information provided by the BREF could partly help OECD countries to evaluate what is technically and economically achievable in terms of best environmental performance within waste management facilities. It has been designed for the European Union only and for installations with a capacity over 10 tonnes per day of hazardous wastes treated, over 50 tonnes per day of nonhazardous waste treated or 3 tonnes per hour for incineration. This covers large as well as medium-sized facilities. Much of the guidance is also potentially useful for small installations. The

BREF could be used as guidance towards applying BAT in the context of the OECD ESM Recommendation.

In a recent paper the Danish Waste Association - RenoSam /31/ has stated that hazardous waste is the type of waste that poses the biggest potential environmental problems. Even small amounts of hazardous waste may potentially lead to significant detrimental effects on health and environment.

Hazardous waste that is recycled or reused contains the same dangers. Recyclable hazardous waste is also a local irritant, poisonous, corrosive, carcinogenic, and harmful to reproduction or may lead to early death.

RenoSam therefore argues that hazardous waste must be under tight management. There must be careful management of hazardous waste whatever treatment it receives. It is very important that hazardous waste is collected, handled and treated in an environmental sound manner and with stricter monitoring and control than for other types of waste.

As much hazardous waste as possible must be recycled or utilized (e.g. by energy recovery via incineration), and as little as possible must go for landfill /31/.

The central challenge to develop a successful HWM program is creating incentives for proper hazardous waste treatment and disposal. The demand for HWM services is driven largely by regulation, whether it is command and control type or more market based approach. Generators of hazardous waste must have incentives (of either "carrot" or "stick" variety) to treat and dispose of waste properly and to pay the associated costs.

One of the concerns about tightening up the regulatory system is that it makes proper waste treatment and disposal more expensive, creating a powerful incentive for *improper* disposal. In the early years of many countries HWM programs for proper hazardous waste treatment and disposal "competed with the river", with the cost of disposal being effectively zero. It takes time to build a regulatory system that can discourage such low-cost and environmentally harmful waste management practice. It takes a long time until one can say that a "culture of compliance" exists among generators and that proper waste management is a norm rather than the exception /3/. This starts with that everybody caring for environment in their country support the establishment of a proper HWM program.

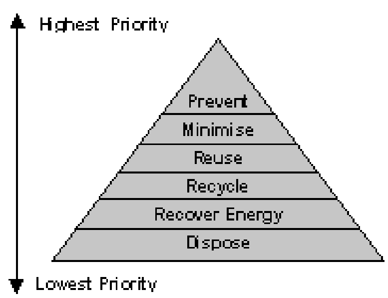
However, the advantage of South Africa is that an understanding of the importance of proper hazardous waste management already exists. A number of landfills designed specifically for hazardous waste are in operation, although on-site disposal of waste at industrial sites are less controlled. Limited but controlled incineration/pyrolysis of hazardous waste also occurs. The problem is that there might be a need for introducing a replacement of the landfill system with an incineration based system, which is friendlier to the environment, but also is more expensive. Furthermore, there is a clear need for monitoring, controlling and enforcing that generated hazardous waste is registered and re-

ceives a documented approved final treatment or disposal in accordance with set rules and policies, supported by an effective combination of regulatory and fiscal incentives/disincentives and with the prospect of severe punitive measures in the event of misconduct.

4.1 Overview of hazardous waste treatment technologies

Hazardous waste treatment is a rapid developing industry full of innovation. This innovation is being driven by the need for effective and economical processes for treating wastes rather than landfilling them without treatment. A hierarchy of general wastes options can be constructed where the most desirable option is source reduction:

In June 2007 the EU Environment Council reached a unanimous decision on proposals to revise the waste management rules, voting for a five-step waste hierarchy, prioritising: prevention, reuse, and recycling ahead of energy recovery and disposal. Waste incineration was hereby reclassified as “recovery” rather than “disposal”.



Waste Management Options and Priorities

1 Source reduction (process modification)
2 Separation and volume reduction
3 Exchange/sales as raw materials
4 Energy Recovery
5 Treatment
6 Secure ultimate disposal (landfilling, encapsulation)

There is a lot to gain from point 1-4, but the incentives for doing that are first really obvious to the plant owners if they have to pay a price to get their waste treated correctly. Therefore, it is often seen that for some years initially a bigger amount of waste are sent for treatment, and later the companies can see the advantage of source reduction, substitution etc., resulting in waste reduction.

When it comes to treatment of hazardous organic compounds incineration is widely perceived as preferable to most other treatment or destruction processes (e.g. countries with very good control of their waste streams as EU (27 countries) Canada and USA, but also of Malaysia, Thailand, and Japan)/5/. Several incinerator configurations and processes have been developed.

Depending of the type of hazardous waste it may be treated in different ways. Some well known technologies are:

- Landfills
- Cement kilns
- Incineration in rotary kilns,
- Fluidized - bed incineration
- Plasma Systems
- Pyrolysis processes
- Liquid injection incinerators
- HW as fuel for boilers
- Wet oxidation
- Asphalt blending
- Molten Glass Processes
- Super critical water oxidation

A description of many of the technologies may be seen at ref. /70/.

According to Basel Guidelines on Hazardous Waste from the Production and Use of Organic Solvents /92/ incineration does provide the generally accepted disposal route for solvent wastes not being recovered. Other possibilities may sometimes exist, although these alternative options are not equally appropriate or equally satisfactory in all circumstances. Incineration is a very flexible technique in that by judicious selection of incinerator design and of the various options for combustion gas cleaning, together with operating conditions selected for the purpose, a plant can be able to handle many types or combinations of waste. Incinerators may sometimes be constructed as part of a manufacturing process, to deal with the waste streams from that process. In such cases, the nature and composition of the wastes will usually be reasonably well defined, and the plan can be designed and constructed on the basis of a narrow scope of operation.

5 Non-incineration Technologies for Hazardous Waste Treatment

According to the Stockholm Convention on POPs, the irreversible destruction of POPs or their transformation into other non-POP molecules is the preferred action. There is a limited number of technologies that can be effectively applied to concentrated chlorinated chemicals. Three principal requirements for the choice of the most appropriate destruction technology for concentrated POPs apply

1. It should be applicable to concentrated POPs (stockpiles)

2. It should guarantee complete and efficient destruction of POPs. Only chemical physical technologies can provide fast and efficient decomposition of the POP molecule. Bio-treatment options are not suitable for destruction of concentrated chemicals.

3. It should guarantee that no new POPs are formed and released

The destruction technologies that are suitable for destruction of POP stockpiles (POP destruction technologies) are usually divided into two groups:

1. Incineration technologies and

2. Non-incineration technologies

5.1 International Reviews of Non-incineration Technologies

5.1.1 UNIDO Review of non-combustion POPs Destruction Technologies.

A review of non-incineration technologies for POPs destruction has been published by UNIDO in 2007 /86/. It should be noted that the destruction of PCBs and other POPs is more demanding than the destruction of most other hazardous wastes because of the high content of chlorine and the presence of precursers for formation of chlorinated dioxins and furans.

The review has selected 15 non-incineration technologies for evaluation:

1	Ball Milling	(Mechano Chemical De-halogeneation)
2	BCD	(Base Catalysed Decomposition)
3	CerOx	(Mediated Electrochemical Oxidation by Ce(IV)
4	GeoMelt	(Destruction in the Soil Melt)
5	GPCR	(Gas-Phase Chemical Reduction)
6	HydroDec	(Hydro-de-chlorination)
7	MSO	(Molten Salt Oxidation)
8	PACT	(Plasma Arc Centrifugal Treatment)

9	Plascon	(Plasma Conversion)
10	PWC	(Plasma Waste Converter)
11	SCWO	(Supercritical Water Oxidation)
12	SET	(Solvated Electron Technology)
13	Silver II	(Mediated Electro Chemical Oxidation by Ag(II))
14	SPHTD	(Self-Propagating High Temperature De-halogenations)
15	SR	(Sodium Reduction)

The 15 technologies considered in the review are classified as:

Table 3 Non-incineration technology classification

Established	Emerging	Transition	Promising
GPCR	Ball Milling	CerOx	HydroDec
BCD	SWCO	GeoMelt	Silver II
Plascon	SET	PACT	SPHTD
SR		MSO	
		PWC	

In the report the technologies are evaluated, but it is up to future investors to finally decide if these technologies are feasible or not in practical life.

5.1.2 UNEPs Survey of Non-incineration PCB destruction

A questionnaire was prepared and distributed in early 2004 to certain companies and to national POPs Focal Points. The questionnaire sought information on the geographical distribution of facilities that treat PCB wastes, licensing, availability of mobile technologies, storage capacity, major concerns and research needs in relation to PCB management, PCB waste accepted, technologies used for the disposal of PCBs or the decontamination of PCB wastes, pretreatment procedures, monitoring and control of releases, treatment costs, treatment capacity, and adaptation to higher or lower capacities. A summary of the results obtained from the analysis of the questionnaires received by UNEP Chemicals received is presented in the report /93/.

High temperature incineration technology is the main method used for the destruction of PCBs (18 facilities), followed by the well-established Sodium Reduction non-combustion technology (8 facilities).

Other technologies, such as the Gas Phase Chemical Reduction (GPCR) (3 facilities), the Base Catalysed Decomposition (BCD) (2 facilities), Plasma Arc (3 facilities), and pyrolysis/gasification (1 facility) play a lesser role in PCB destruction.

The catalytic oxidation (TiO_2 based V_2O_5/WO_3) catalyst process does not exist as a commercial unit, although this technology is applied in other industrial units for the destruction of chlorinated volatile organic compounds (Cl-VOCs) and PCDD/PCDF and PCB abatement in off-gases and could be used with minor changes (desorption unit) for PCBs/POPs destruction.

Super-Critical Water Oxidation (SCWO), Solvated Electron Technology, and Molten Salt Oxidation are currently not used for PCB waste disposal.

The main applied technology for recycling and reuse of PCB-contaminated equipment/material is solvent decontamination (12 facilities), followed by thermal desorption (3 facilities), retro-filling (2 facilities) of electrical equipment, and the detoxification technology (1 facility). It should be noted that some companies apply more than one technology for PCB waste destruction or recycling and reuse of PCB-contaminated equipment/material.

5.1.3 Basel Convention Guidelines

Managing hazardous or other wastes in an environmentally sound manner is a fundamental obligation of Parties to the Basel Convention. Work is being carried out in that context to help Parties, in particular developing countries, to apply environmental sound management (ESM) principles. A number of technical guidelines developed within the Basel convention, have been developed for specific waste streams, such as used tyres, plastic waste, lead-acid batteries, ships, biomedical and healthcare waste /90/.

In the context of a partnership on mobile phones, guidelines on the environmentally sound management of end-of-life mobile phones are under development. Such guidelines are particularly useful for developing countries insofar as the elaboration of their waste management infrastructure may still be at an early stage and they may not yet possess environmental know-how and technologies required to ensure ESM. In this way, developing countries can benefit from the experience of developed countries.

In the context of POP waste the Basel Convention has issued a "Training Manual for Hazardous Waste Project Managers" on Destruction and Decontamination Technologies for PCB's and other POPs Wastes /95/.

Several POPs destruction technologies are described here

Established
- Incineration (HTI)
- Thermal desorption
- De-chlorination
- Solvent Extraction

Emerging
- Solidification
- Stabilisation
- Bioremediation
- Vitrification
- Ball Milling

Other Waste Guidelines

The Technical Working Group of the Basel Convention, a subsidiary body to the Conference of the Parties, has been established to prepare, as its main task, the technical guidelines referred to above. As of today, the Technical Working Group has completed the following tasks /94/

1) Preparation of the Framework Document to be used as a guideline in the preparation of the Technical Guidelines for the Environmentally Sound Management of Wastes subject to the Basel Convention, adopted by the second meeting of the Conference of the Parties.

2) Preparation of a Guidance Document on Transboundary Movements of Hazardous Wastes Destined for Recovery Operations. The Guidance Document is meant to assist countries in their efforts to ensure, as far as practicable, the environmentally sound management of wastes subject to the Basel Convention within their national territory.

3) Preparation of a set of four Technical Guidelines on Priority Waste Streams (namely: Hazardous Waste from the Production and Use of Organic Solvents; Waste Oils from Petroleum Origins and Sources; Wastes Collected from Households, adopted at the second meeting of the Conference of the Parties and Technical Guidelines on the Identification and Management of Used Tyres adopted at the fifth meeting of the Conference of the Parties.

4) Preparation of a set of three Technical Guidelines on disposal operations (namely: Specially Engineered Landfill, Incineration on Land, and Used Oil Re-refining or other Re-uses of Previously Used Oil, adopted at the third meeting of the Conference of the Parties. At the fifth meeting of the Conference of the Parties, Technical Guidelines on Physico-chemical and Biological Treatment were adopted.

5.1.4 Danish EPA Review of POPs Destruction Technologies

A detailed technical, environmental and economic review of in total 4 pre-selected incineration and non-incineration destruction technologies for POPs was carried out by the Danish EPA (2002-2003) /4/. The pre-selected technologies are all commercially available on the world market and have all been reviewed in operational mode. The pre-selection process involved a global screening of available POPs elimination options and based on in-meeting with major NGO organisations like Greenpeace International, Pesticides Action Network-UK, International Pesticides Elimination Network (IPEN) and the International HCH & Pesticides Association, 4 potential technologies were selected for independent, but comparable review:

- Container-based Incineration System (CIS)
- Cement Kiln Incineration (CKI) representing the incineration based technologies
- Gas Phased Chemical Reduction (GPCR) and

- Base Catalysed De-chlorination (BCD) representing the non-incineration technologies.

The detailed review involved a number of environmental, technical and economic review criteria, which in advance have been reviewed and agreed upon by major advisory NGO organisations. The environmental criteria covered materials used for construction of the elimination plant, means of operation, efficiency of the elimination process, emissions to air, water and soil and residues. The technical review criteria included environmental and economic impact, capacity of the technique, comprehensiveness, robustness and maintenance possibilities and expenses, capacity building, supply lines, generation, residual products, occupational health and operational risks while the economic criteria included organisation, transfer of know-how, capacity, logistics, process residues, demands, direct and in-direct costs assessment.

Based on an evaluation mask taking all reviewed criteria into balanced consideration, the following can be concluded:

- The CIS and GPCR POPs elimination technologies are found equal in appropriateness, market availability, affordability and operational performances taking into account possible environmental impact, use of supply lines and risk potential;

- The BCD technology is characterised by having lower capacity, high use of supply lines and relatively less affordable; while

- The cement kiln incineration is characterised as "a way through". CKI is not a dedicated technology but more a symbiotic system where high temperature destruction and need for energy-intensive fuel can allow for hazardous waste destruction, and many resources are used for other purposes than purely e.g. POPs treatment.

Now in 2007 it is believed that cement kilns under correct circumstances is capable of treating certain hazardous waste streams properly /76/,

However this report considers only the destruction of small amounts of hazardous waste (POP-waste), and is not considering daily destruction of big amounts of waste. Seen in that perspective both the GPCR and the BCD technology have limitations especially because they are operating batch wise and not continuously.

An important conclusion of this report is also that BCD and GPCR at that time was the only two proven non-incinerating techniques available on the marked for destruction of hazardous waste and probably still are.

5.2 Landfilling of Hazardous Waste

In 1999 the EU commission adopted the Landfill Directive 1999-31-EC /27/ and Council Decision establishing criteria and procedures for the acceptance of waste at landfills 2003-33-EC /28/ that put up a scheme for how much organic municipal waste that may be disposed of at a landfill.

The overall aim of the Directive is, whilst recognizing that there will always be a need for landfill disposal, to reduce as far as practicable the environmental impact of landfills, in terms of: /79/

- avoiding the disposal of raw, untreated wastes which are likely to produce toxic/hazardous leachate

- reducing the use of landfill for biodegradable wastes, which produce both methane (adding substantially to the global warming problem) and strong leachate

- ensuring that landfills that are needed are engineered, monitored and controlled, both in operational and aftercare phases, as well as possible.

Furthermore/79/:

- in 2006, biodegradable municipal waste going to landfills must be reduced to 75 % of the total amount of biodegradable municipal waste produced in 1995;

- in 2009, biodegradable municipal waste going to landfills must be reduced to 50 % of the total amount of biodegradable municipal waste produced in 1995;

- in 2016, biodegradable municipal waste going to landfills must be reduced to 35 % of the total amount of biodegradable municipal waste produced in 1995.

At the same time there has been put down strict regulation for landfilling of hazardous waste. Beside a long row of leaching limits have been established, e.g. leachate from hazardous waste must only contain maximum 6 % Total Organic Carbon (TOC) and pH must be minimum 6.

The Directive /78/ is intended to prevent or reduce the adverse effects of the landfilling of waste on the environment, in particular on surface water, groundwater, soil, air and human health.

It defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land. Landfills are divided into three classes:

- landfills for hazardous waste;
- landfills for non-hazardous waste;
- landfills for inert waste.

On the other hand, the Directive does not apply to:

- the spreading on the soil of sludge's (including sewage sludge's and sludge's resulting from dredging operations);

- the use in landfills of inert waste for redevelopment or restoration work;

- the deposit of unpolluted soil or of non-hazardous inert waste resulting from prospecting and extraction, treatment and storage of mineral resources as well as from the operation of quarries;

- the deposit of non-hazardous dredging sludge's alongside small waterways from which they have been dredged and of non-hazardous sludge's in surface water, including the bed and its subsoil.

A standard waste acceptance procedure is laid down so as to avoid any risks:

- waste must be treated before being landfilled;

- hazardous waste within the meaning of the Directive must be assigned to a hazardous waste landfill;

- landfills for non-hazardous waste must be used for municipal waste and for non-hazardous waste;

- landfill sites for inert waste must be used only for inert waste.

The following wastes may not be accepted in a landfill:

Liquid waste; flammable waste; explosive or oxidizing waste; hospital and other clinical waste which is infectious; used tires, with certain exceptions; any other type of waste which does not meet the acceptance criteria laid down in Annex II of the directive.

This implies that organic hazardous wastes are not to be landfilled *without prior treatment* if they exhibit total contents of leachability of potential hazardous components that are high enough to constitute a short-term occupational or environmental risk or to prevent sufficient waste stabilisation within projected lifetime of the landfill.

The Directive sets up a system of operating permits for landfill sites. Applications for permits must contain the following information:

- the identity of the applicant and, in some cases, of the operator;
- a description of the types and total quantity of waste to be deposited;
- the capacity of the disposal site;
- a description of the site;
- the proposed methods for pollution prevention and abatement;
- the proposed operation, monitoring and control plan;
- the plan for closure and aftercare procedures;
- the applicant's financial security;
- an impact assessment study, where required under Council Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment.

EU Member States must ensure that existing landfill sites may not continue to operate unless they comply with the provisions of the Directive as soon as possible.

Member States must report to the Commission every three years on the implementation of the Directive.

On the basis of these reports, the Commission must publish a Community report on the implementation of the Directive;

The new landfill legislation has the impact that much more municipal waste that cannot be recycled must undergo either Mechanical - Biological Treatment (MBT) or incineration.

Still half of the countries/regions are landfilling more than 50 % of the biodegradable municipal waste /79/. This now has to change in the years to come in order to follow the intentions in the landfill directive, and there is a tendency that incineration is gaining ground, but also MBT is growing. MBT technology is big in Germany and Austrian and emerging in the UK, Italy and Ireland and incineration is big in Denmark, Sweden, Switzerland, the Netherlands, France Germany and Norway /79/.

In the whole world/80/ landfill is currently the most widespread treatment method. In developing countries, illegal dumping and informal recycling sector (primarily based on the work of the poorest urban populations) still remain the most popular methods of waste disposal today. A classification of countries by treatment method confirms a relatively complex reality:

- countries in which the landfill rate exceeds 40%:
  Hong Kong, new EU member countries, Australia, USA, South Korea,

- countries in which the incineration rate is greater than or equal to 20%:
  EU15, Taiwan, Singapore, Japan,

- countries in which the rate of illegal dumping exceeds 30%:
  Morocco, Mexico, Turkey, African countries.

As indicated above some countries/80/ have relatively high ratios of incinerated municipal waste per inhabitant. This is the case in some Asian countries (Japan and Singapore) and in some European countries (Denmark, Switzerland, the Netherlands, Norway, Sweden and France) who have introduced preferential rates for this energy (purchase of green energy, “green certificate”).Other countries such as the UK, the USA or Canada have not really developed this industry, which is nevertheless expanding. A European directive sets an objective of 12% of gross domestic energy consumption and 22.1% of electricity produced using renewable resources by 2010.

As with the development of pre-treatment prior to the landfilling of municipal waste in Europe, this directive aims to limit and to stabilize the organic fraction and to provide Refuse-derived Fuel (RDF). It will also promote the development of waste-to-energy. A country such as the UK could thus strongly increase its incineration capacity over the next few years. Rising energy costs, safety and energy independence, the control of greenhouse gas emissions, compliance with the Kyoto Protocol and improved environmental performances (progress in the strict control of pollutant emissions and in combustion management) are all factors that contribute to the development of this method /80/.

Hence, in most of EU countries the need for more energy from waste capacity can be felt, due to the new landfill legislation, demanding less organic waste disposed to landfills.

Therefore the tendency in Europe is that there will be build more MBT and Waste-to-Energy (WTE)-plants for increased diversion of municipal and hazardous waste from landfills. Which of the two technologies that will dominate in a particular EU member state depends largely in local political sentiments, existence of incentives for producing CO2 neutral energy from waste and the national adaptation of the landfill directive and interpretation of what constitute "pre-treated waste"? I.e. shall waste to be landfilled be truly inert, or shall the quantity of biodegradable content merely be reduced below a certain level, before landfilling.

During the period 2002-2005, two major studies were carried out to provide comprehensive information on dioxins, furans and PCBs in EU-10. The results were discussed at a workshop organised in Brussels in February 2005 (see annex 4) during which implementation of existing legislation and increased attention to small domestic sources were identified as priorities for future work /32/.

A general reduction of dioxin, furan and PCB levels in the environment and humans has already been achieved over the past two decades, in particular through control of industrial emission sources, like waste incineration. In view of the persistence of these chemicals, it is however appropriate to continue working for the reduction of the anthropogenic emissions to the environment, with the goal of their continuing minimization and, where feasible, ultimate elimination /32/.

6 Incineration of Waste

6.1 International Policies and Strategies

In the **European Union (EU),** waste management is almost totally regulated by EU directives, which supply a framework for national regulations. The main target in view of sustainability is the prevention of direct disposal of reactive waste in landfills. The tools to comply with these principles are recycling and material recovery as well as waste incineration with energy recovery for final inertization. The adaptation of the principles laid down in EU directives is an ongoing process.

A number of countries have already enacted respective national regulations and their realization shows that recycling and incineration are not in competition but are both essential parts of integrated waste management systems. Hence, EUROSTAT EU waste statistics show that those countries that incinerate the most are also those countries that recycle the most, whereas those countries that have no incineration are the ones that landfill the most and recycle the least waste.

In the EU, the amount of residual waste available for energy recovery can supply approximately 1% of the primary energy demand. About 50% of the energy inventory of municipal solid waste (MSW) in most EU countries is of biogenic origin, and MSW is to the same extent to be looked upon as regenerative fuel. Hence part of the CO_2 released from waste incineration is climate neutral. In the EU, this share could produce savings of the order of 1% of annual CO_2 emissions if energy from MSW replaced that derived from fossil fuel /96/

In **USA**, most industrial processes produce waste which the U.S. Environmental Protection Agency (EPA), acting under the Resource Conservation and Recovery Act (RCRA), has determined can be detrimental to public health or the environment if not properly managed /97/

Hazardous wastes are generated, for example, in the production of cosmetics, pharmaceuticals, detergents, household paint and cleaning products, light bulbs, telephones, televisions, newspapers, garden pesticides, computers, chemicals, gasoline, and even automotive safety devices such as air bags.

Companies have made considerable strides in recent years to reduce or recycle hazardous wastes from their production processes. They have been encouraged to do so by public policies and by their own economic interests in reducing their cost of waste disposal. The high cost of incineration, relative to other forms of treatment or disposal, has been an incentive to reduce the generation of combustible wastes.

Nevertheless, more than 200 million tons of hazardous wastes are generated annually, and large amounts of hazardous waste will continue to be generated in the future even under optimistic but realistic expectations.

Moreover, many industrial wastes which are not yet defined as hazardous should be brought under hazardous waste regulation in the future. For example, there are over 30,000 government registered pesticides that contain toxic and hazardous constituents, of which fewer than 20 are regulated now as hazardous waste when discarded. Future federal regulations should define more of these and other wastes as hazardous, as many states presently do.

In light of the risk these unregulated wastes pose, many responsible companies presently send their non-regulated industrial wastes to commercial incineration facilities for safe and proper treatment.

Another major area of need for waste treatment and disposal is the clean up of contaminated sites. USA's worst environmental sites are listed in the National Priority List under the Superfund program. The toxic materials from these sites should be properly treated and disposed. As of year 2000, of the 1,228 Superfund sites, over 757 have not completed construction of remedial actions. As many as 3,000 other contaminated sites will need to be addressed through the corrective action program. A top priority in this USA environmental program must be the clean up of problem sites that pose a risk to human health and the environment.

In order to treat these wastes, destruction in high temperature incinerators has been determined by EPA, after extensive expert and public review, to be the Best Demonstrated Available Technology (BDAT) for most organic hazardous wastes. This is because incineration safely and effectively destroys the hazardous constituents in the waste, as discussed in the subsequent sections of this report.

In the U.S., modern hazardous waste incineration is a widespread technology. Most hazardous waste incinerators (136 of a total of 164) are owned and operated by the factory or other facility that generates the waste, and are located on the generating site. Fewer than 30 incinerators that accept off-site generated wastes (i.e., "commercial" incinerators) serve small businesses and other generators who cannot effectively or economically incinerate their hazardous wastes on-site. Today, 95% of hazardous waste generators, including many small businesses, depend entirely on off-site facilities for management of <u>all</u> of their hazardous wastes.

In short, high temperature incineration will continue to play an important role in the future for the safe and effective treatment of much of the organic hazardous wastes that will continue to be generated by U.S. industry. It is also a necessary component, as noted above, of the clean up of organic wastes at thousands of existing Superfund and other remedial sites /97/

ISWA (International Solid Waste Association) has a policy on HWM that supports the separate handling of hazardous waste at designated hazardous waste treatment facilities as an element of integrated solid waste management, and supports the idea of keeping hazardous components apart from other waste streams /98/

ISWA supports the idea of focusing on the producers of goods to prevent hazardous components in new products. By separate treatment at designated hazardous waste facilities outdated and prohibited chemicals can be phased out.

The following are considered to be best practice in the siting, design, and utilization of hazardous waste treatment facilities as part of integrated waste management:

1. Sites for hazardous waste treatment facilities should be selected based on the following principles:

- capability of being engineered to provide for best practices in design and operation,
- siting in locations which are compatible with existing land use practices

2. Designated hazardous waste treatment facilities should be established for various hazardous waste streams among others:

- thermal treatment facilities - high temperature treatment for hazardous wastes comprising halogens
- physical/chemical treatment facilities
- controlled landfilling

3. Hazardous waste treatment facilities shall be designed by registered professional engineers and other licensed professionals, with demonstrated knowledge in hazardous waste, to prescribe to the following principles:

- means for the measurement of incoming hazardous waste and out-shipped residues,
- means for the screening and chemical analyzing of incoming hazardous waste ,
- control of run-on and run-off to minimize to prevent surface water contamination,
- prevention of air quality contamination,
- incorporation of air quality monitoring systems,
- provision for the safe interim storage of hazardous waste.

4. Operation of hazardous waste treatment facilities shall prescribe to the following principles:

- operation under the management of a provincial/state certified manager/operator in those provinces/states where certification is required,

- provision for controlled access and use by only authorized users,
- measurement and registration of all incoming hazardous waste,
- acceptance of no wastes not included in the design and permit conditions,
- provision for training of on-site personnel, and
- own safety and fire protection staff where needed.

6.1.1 EU BAT reference document on incineration

According to the EU BAT reference (BREF) document on waste incineration, /7/ at the time of its compilation (2006):

- Around 20 - 25 % of the municipal solid waste (MSW) generated in the EU-15 is treated by incineration (total MSW production is close to 200 million tonnes per year);
- The percentage of MSW treated by incineration in individual Member States of the EU-15 varies from 0 % to 62 % ;
- The total number of MSW installations in the EU-15 is over 400;
- Annual MSW incineration capacity in individual European countries varies from 0 kg to over 550 kg per capita;
- In Europe the average MSW incinerator capacity is just less than 200,000 tonnes per year;
- The average throughput capacity of the MSW installations in each member state also varies. The smallest plant size average seen is 60,000 tonnes per year and the largest close to 500,000 tonnes per year;
- Around 12 % of the hazardous waste produced in EU-15 is incinerated (total production close to 22 million tonnes per year and not all HW may be incinerated);
- Expansion of the MSW incineration sector is anticipated in Europe over the next 10 – 15 years as alternatives are sought for the management of wastes diverted from landfill by the Landfill Directive and both existing and new Member States examine and implement their waste management strategies in the light of this legislation.

6.2 Applied Incineration Technologies

Incinerator types may be divided into rotary kiln types, gasification types, liquid injection and fluidised bed types.

As can be seen from Table 4 hazardous waste incineration technology may deal with most kind of waste types, but also fluidized bed and cement kilns can treat many types of waste.

Table 4: Commercially used incineration technologies /69 /

Incinerator Types		Incineration Temperature		Waste Types				
		primary chamber	secondary chamber	L	S_{pu}	S_{np}	S_{ut}	S_{pt}
rotary kiln types	hazardous waste kiln	1000 - 1200 °C	1100 - 1400 °C	x	x	x	x	x
	cement kiln*	1600 - 2000 °C	-	x	x	x	-	x
	lime kiln*	1600 - 2000 °C	-					
gasification types	fixed bed gasifier	800 - 1300 °C	-	-	x	x	x	x
	BGL gasifier	1400 - 1600 °C	-	-	x	x	-	x
	entrained flow gasifier	1600 - 1800 °C	-	x	x	-	-	-
liquid injection types	direct injection	1500 - 1900 °C	-	x	-	-	-	-
	co-injection	1400 - 1800 °C	-	x	x	-	-	-

L: liquids with solids = 5%wt.
S_{pu}: sludge, pumpable at ambient temperature
S_{np}: not pumpable at ambient temperature
S_{ut}: solids, untreated bulk type
S_{pt}: solids, pretreated granular type
* typically limitated in Cl-input

Commercially Used Incineration Technologies

If we, however, look around the world and try to see what kind of technology is the most used for HW treatment, it is obvious that many technologies have been used, and most certainly for special cases special technologies have their advantage, but for destruction of large amount of hazardous waste in a safe efficient and cheap way the most used treatment technology is rotary kiln incineration.

Rotary kiln hazardous waste incineration has been used in:

- Finland (1 or more)
- Sweden (1 or more)
- Denmark (3-4)
- Germany (28 or more)
- United Kingdom (2-3 or more)
- Holland (1 or more)
- Belgium (1 or more)
- Austria (1 or more)
- Switzerland (1 or more)
- France (6-?)

- Spain (1 or more)
- USA (164)
- Canada (1 or more)
- Hong Kong (1 or more)
- Japan (?)
- Poland (1-2)
- Latvia (being build) (1)
- Lithuania (being build) (1)
- Other countries

The numbers of plants in the brackets are only indicative. In Germany it is for example known that some bigger companies may have 3-6 incinerators just for their own purpose. The same may be seen in Switzerland and in other countries. However, the conclusion, based on the numbers of incineration plants, is that rotary kiln incineration seems to be the most economic and efficient way to incinerate hazardous waste and the common choice

6.3 Operational Regime

The rotary kiln system has proven especially good for hazardous waste treatment because a rotary kiln can handle solids, solvents and gases at the same time. For municipal waste, normally all solid waste, a roasting furnace grate is the normal device.

The functional basis for all kilns is the same and can be characterised with the 3 **T**'s (**T**emperature, **T**ime, and **T**urbulence).

6.3.1 Temperature

Through the years a lot of time and resources have been spent on optimisation of the operational temperature in the different kiln designs. Normally the kiln for incineration of hazardous waste is not that long, about 10-12 m and with a diameter of 3.5-5 m and the temperature in the kiln is normally kept at 1,100-1,300°C. However, the demands of the authorities are not pointed at the temperature in the kiln but in the secondary incineration chamber (the last place the gasses are destroyed). By incineration of halogenated compounds containing more than 1 % chlorine the EU authorities demands a temperature of minimum 1,100°C (1200 ºC in USA). When chlorine is present the risk of producing dioxins and furans is higher, and in order to ensure that all PCCD/F [1] are destruc-

[1] PCDD/F (often designated "dioxins' and furans" is used as abbreviation for a group of more than 200 individual chlorinated chemical compounds, all of which are of different toxicity. They cause chloric acne and are carcinogenic. Dioxins and furans will form spontaneously from chlorine atoms, carbon that has not been fully oxidised, and various catalysts in cooling smoke; hence, the process is the same for waste incineration plants and tiled stoves alike. Each of the 200 dioxin and furan compounds is of a different degree of toxicity; for that reason, their so-called toxicity units (TUs) are determined and summarised into units of grams per toxicity unit (g TU)

ted the temperature must be raised to 1100 ºC. The temperatures (in EU) must be minimum 850 ºC if the content of chlorine is below 1 %.

Comment: According to Schedule 2 of the SA Air Pollution Prevention Act, the demand to the secondary combustion chamber follow EU-demands (>1100 ºC in > 2 seconds and O_2-conc >11 %)

6.3.2 Retention Time

The retention time for the gasses in the secondary incineration chamber is very important for the efficiency of the incineration process. Normally a retention time for the flue gasses in the secondary incineration chamber must be minimum 2 seconds at 1,100°C if the waste contains more than 1 % chlorine. The retention time can be lower by higher temperatures.

6.3.3 Turbulence

The above mentioned demands are insufficient if not all the gasses are exposed to these conditions. To secure this there is a demand that the turbulence shall be correct in the secondary incineration chamber. A Reynolds number of larger than 65,000 is looked upon as a suitable measure for the turbulence. The turbulence secures a level or efficiency of mixing to ensure whole gas volume exposed to necessary temperature level.

Comment: The turbulence is normally not stated in the standards from the authorities, but is used by the plant producer to demonstrate total mixing of the gasses.

6.3.4 Destruction and removal efficiency

Hazardous waste incinerators have a main chamber for incineration of wastes and a secondary incineration chamber to achieve maximum destruction of hazardous organic by-products. Air and natural gas are burnt to keep the combustion gases at the appropriate temperature (1,100°C) for at least two seconds (residence time). Off gases are cooled to approx. 200 °C before entering the gas cleaning processes.

Properly managed incineration must destroy pesticide waste with a Destruction and Removal Efficiency (DRE) of 99.99 percent (and 99.9999 % for dioxin containing waste). Some incinerators even claim DRE values of up to 99.99995 percent. However, the DRE is defined as DRE = $(M_i-M_s)/M_i$ x 100, where M_i is the mass of a chemical fed into the destruction system during a known period of time and M_s is the mass of the chemical released in stack gases during the same period of time. The releases of chemicals via fly ash, bottom ash and scrubber water is not reported this way.

A better measurement of destruction is the "Destruction Efficiency (DE)" which is defined as DE= $(M_i -M_o)/M_i$ x 100, where M_i is the mass of a chemical fed into the destruction system during a known period of time and M_o is the mass of that same chemical released in stack gases, fly ash, scrubber water, bottom ash and any other incinerator residue.

This principle shall also cover when reporting on the generation of products of incomplete combustion (PIC). The most famous PICs are dioxins and furans and when the emission of PICs are reported is must also cover the mass of PICs that is released in stack gases, fly ash, scrubber water, bottom ash and any other incinerator residue.

As all organic materials are destructed by the incineration, the PICs are formed after the incineration process by the so called *de novo* synthesis. Factors which influence the de novo synthesis has been thoroughly studied in the last 20 - 30 years, and some of the important direct factors are temperature, chlorine concentration, concentration of catalysts, carbon and oxygen, but also secondary factors must be considered. Some results are that /36/

- Even after complete combustion, dioxins and furans may be reformed at temperatures between 200 ºC and 650 ºC by *de novo* synthesis

- Both organic bound chlorine (e.g. PVC) and inorganic chlorides (e.g. NaCl) may function as chlorine source. However, inorganic chlorides have a rather slow reaction pathway

- Both copper and iron can function as catalysts for the formation of dioxin, although copper is 10 times as effective as iron. However the iron catalyst may give the biggest contribution to the dioxin formation as there often is much more iron present in the flue gas dust.

- Oxygen in high concentration and at high temperature (> 650 ºC) increase destruction of all organics, whereas oxygen in high concentration and low temperatures (200-650 ºC) increase dioxin and furan synthesis.

The lessons from such studies are now being used in construction of new hazardous waste incinerators.

Next chapter will be dealing in more details with the generation of PCDD/F.

6.3.5 Stack Height

Incineration is a high-temperature thermal oxidation process in which organic molecules are decomposed into gases and non-combustible solids. The Danish waste policy encourages using waste incineration in stead of landfilling (see Annex 5). The solids consist of ash, flue gas cleaning products and bottom ash and are disposed of by landfilling. Stack gases are largely water vapour and carbon dioxide, but will include very small quantities of acid gases, toxic gases like dioxins, and toxic ash and metal oxide particles also. To control pollution, incinerators are equipped with gas cleaning equipment, such as scrubbers, electrostatic filters, bag house filters, NOx removal and activated carbon filters and a stack.

The stack heights are calculated using meteorological air quality models/Air Dispersion Models. In Denmark the so called OML-model (Operationel Meteorologiske Luftkvalitetsmodel (Operational Meteorological Air quality model)) is used.

The OML model is based on ambient air quality calculations of concentration and smell of pollutants. The model also rectify for heights of neighbouring buildings or difference in ground level and their effect on turbulence. The model can also rectify for receptor heights (e.g. high buildings with people in) but normally a receptor height is 1.5 m.

Finally, the OML model also includes calculations of stack height on basis of wind direction frequency, and emission amount (Nm^3/ hour emitted above the stack). Based on this the stack heights of incineration plants in Denmark have been calculated to between 70 m - 100 m.

Comment: According to Schedule 2 of the SA Air Pollution Prevention Act, the demand to chimney heights seems rather vague, as the chimney shall have a minimum height of 9 meters above ground level.

6.4 Generation of Residues

The volume reduction of the waste is depending on the waste type. At the incineration process the volume of the waste is typically reduced by about 90 % and its weight with about 70-80 %. In the process several residues are produced that must be handled subsequently. The residues contain products from the incineration as well as unburned materials directly from the stoked waste, and residues from the flue gas cleaning. The normal seen residues will be bottom ash, flue gas ash from the boiler and the economizer plus residues from scrubber cleaning of acidic flue gases. By use of wet scrubbers, there will in addition to the solid residues also be waste water to treat /22/.

Bottom ash, which is formed when the waste is destructed in the rotary kiln, makes up the biggest part of the residues (200 - 300 kg/ton waste). When the bottom ash leaves the rotary kiln it must be cooled. This happens often in water in a bottom ash container (sudden cooling).

Flue gas cleaning products from the boiler (and economizer) consists of rather coarse particles and is often taken out from a chamber below the boiler and stems normally from a layer on the outside of the boiler tubes that is knocked of. The amount of boiler flue gas ash is about 5 kg per ton of waste.

Flue gas ash from the electrostatic precipitator (ESP) and/or the bag house filters (BHF) consist of rather fine particles. The amount of this type of flue gas cleaning product is about 10-30 kg per ton of waste.

From the scrubber section where the acidic flue gas is washed, the particles of heavy metals and rest flue gas cleaning product is separated out. The amount of sludges from this process is about 1-3 kg dry substances per ton waste plus waste water to be treated containing maybe about 8-15 kg calcium and sodium chloride per ton waste.

The removal of dioxin from the flue gas can be done in more ways e.g. by blowing activated carbon into the bag house filters, where after the flue gas ash together with the activated carbon is deposited in hazardous waste landfill, or by using a fixed bed filter where pre-cleaned exhaust gases are conducted at temperatures of 110°–150° C through an activated carbon based adsorbent material. Necessary devices include fresh adsorbent supply, fixed bed reactor and spent adsorbent system. The activated coke bed separates residual dust, aerosols and gaseous pollutants. It is moved cross-current and counter current in order to prevent blockage of the bed through, for example, residual dust /84/.

Another way is the flow injection process where a "police filter" is installed consisting of injection activated carbon into a filter just before the stack, removing dioxin and possible minor amounts of e.g. mercury. This activated carbon is continuous removed and incinerated whereby the trapped dioxin is destroyed /84/.

It is also possible to install catalytic oxidation processes, which are normally used for reducing nitrogen oxide emissions, as this may be applied for PCDD/PCDF destruction as well. Therefore, effective de-dusting (e.g. emission values of particulate matter of below 5 mg/m^3) is a requirement for achieving low overall emissions of unwanted chemicals. For the removal of PCDD/PCDF only (e.g. with the DeDiox process), ammonia injection is not necessary. In this case, operation temperatures range from 130° to 350° C. The main advantages of this process are an easy operation and no residues apart from very little spent catalyst. Therefore, catalytic oxidation does not cause disposal problems /84/.

All in all the amount of residues from a hazardous waste incineration plant lies in the area of 200 - 300 kg per ton of waste. Normally the different streams of ash are treated differently.

From MSW 85-98 % of the bottom ash can be reused in as a product for road construction material (based on a TLCP similar test) /23/. Also bottom ash from hazardous waste incineration plants live up to the Danish requirements for bottom ash for road construction, but is not allowed to be used, because it stems from the incineration of hazardous waste /24/.

Ashes and residues from boilers and flue gas cleaning in the scrubbers on the other hand must be treated as hazardous waste and disposed of in landfills with special handling of leachate /22, 25/. In many countries, ash from MSW incinerations is not considered as an environmental release of PCDD/Fs and it is not included in such an inventory.

Ashes from five state-of-the-art facilities located in different regions of the United States were analysed for all 2,3,7,8-substitued PCDDs and PCDFs. The TEQ levels in the ash (fly ash mixed with bottom ash) ranged from 106 to 466 ng/kg, with a mean value of 258 ng/kg. PCDD/F levels in fly ash are generally much higher than in bottom ash. For example, there have been reported levels of 13,000 ng TEQ/kg in fly ash. Each of the five facilities sampled in USEPA had companion ash disposal facilities equipped with leachate collection systems or some means of collecting leachate samples. Leachate samples were collected and analysed for each of these systems. Detectable levels were only found in the leachate at one facility (TEQ = 3 ng/l).

Regarding dioxin in fly ash and slag from the incineration processes the Danish Hazardous waste Treatment Company - Kommunekemi /100/ have the following measurements from March 2000 have given concentrations of 69 ng I-TEQ/kg and 39 ng I-TEQ/kg respectively equalling a total dioxin quantity of:

- Fly ash approx. 0.4 g I-TEQ/year
- Slag approx. 0.4 g I-TEQ/year

However, modern well-operated plants can be net destroyers of PCDD/Fs, with less of these chemicals existing in the facility via the stack, in wastewater and in solid residues than is introduced via the waste feed /25/.

Consequently, PCDD/F levels in ash have reduced significantly, and are typically ≤0.02 ng I-TEQ/g in bottom ash, and less than 0.3 ng I-TEQ/g in fly ash from pollution control devices. The expectations of PCDD/F concentrations in the ash from modern, well run incineration facilities should be well within the specified limit for ash quality, namely 1 ng I-TEQ/g /25/

A literature review on PCDD/F and related compounds in solid residues from municipal solid waste incineration (grate furnaces) /99/ concludes that organic pollutants, first of all the PCDD/F are of high concern in waste incineration and a lot of efforts have been spent in research and development to minimise their formation as well as their inventory in all residue streams. These activities, however, were mainly directed to the air emission quality. Less work has been done on the solid residue side and there is still lack of reliable data compared with the data bases for other aspects of waste incineration.

However the review of literature and the authors own measurements indicates that modern waste incineration plants with good combustion control produce bottom ashes with inventories of PCDD/F which are not much higher than those in European soils. Hence no further post-combustion treatment is required for abatement of organic compounds. However such quality will only be achieved if stable combustion conditions are established /99/.

6.5 Monitoring

According to the EU Directive on Incineration /73 /, each line of the incineration plant shall be equipped with at least one auxiliary burner. This burner must be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below 850 °C or 1 100 °C as the case may be.

It shall also be used during plant start-up and shut-down operations in order to ensure that the temperature of 850 °C or 1100°C as the case may be is maintained at all times during these operations and as long as unburned waste is in the combustion chamber. During start-up and shut-down or when the temperature of the combustion gas falls below 850 °C or 1100°C as the case may be, the auxiliary burner shall not be fed with fuels which can cause higher emissions than those resulting from the burning of gasoil.

Incineration plants shall be designed, equipped, built and operated in such a way that the emission limit values are not exceeded in the exhaust gas.

For emission to air the hazardous waste incinerators in Europe must comply with the EU-Directive 2000/76/EC and must meet the emission limits for PCDD/F in flue gases < 0.1 ng TEQ/Nm^3 corrected to 273 K, 101,3 Pa, 11 % O_2 and dry gas.

To monitor the process the incineration plant shall carry out the following measurements:

(a) Continuous measurements of:
NO_x, provided that emission limit values are set, CO, total dust, TOC, HCl, HF, SO_2;

(b) Continuous measurements of the following process operation parameters: temperature near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, concentration of oxygen, pressure, temperature and water vapour content of the exhaust gas;

(c) At least two measurements per year of heavy metals, dioxins and furans; one measurement at least every three months shall however be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants

6.6 BAT for Waste Incineration

Best available techniques (BAT) for waste incineration, with particular emphasis on the prevention of emissions of POPs from waste incineration, has been described in detail in the following guidelines from international organisations and the BREF documents from the EU mentioned in the following section:

- Basel Convention Technical Guidelines on Incineration on land /88/;
- Draft Guidelines on Best Available Techniques (BAT) and provisional guidance on Best Environmental Practices (BEP) /84/;
- EU BAT reference document (BREF Document) on Waste Incineration /7/.

6.6.1 Basel Convention Guidelines on Incineration on Land

The Basel Convention has in 1995 published "Technical Guidelines on Incineration on land". The guidelines describe the types of incineration plants possible, control of emissions, selection of waste, monitoring requirements etc.

6.6.2 UNEP BAT/BEP Guidelines

UNEP Chemicals has in 2006 published some revised draft guidelines on Best Available Techniques (BAT) and provisional guidance on Best Environmental Practices (BEP) relevant to production and releases of unintentionally produced POPs covered by Article 5 and Annex C of the Stockholm Convention (84). Chapter V.A addresses waste incinerators while chapter V.B addresses cement kilns firing hazardous waste.

According to the guidelines, the environmentally sound design and operation of waste incinerators requires the use of both best available techniques and best environmental practices (which are to some extent overlapping) to prevent or minimize the formation and release of unintentionally produced POPs.

Best environmental practices (BEP) for waste incineration include appropriate off site procedures (such as overall waste management and consideration of environmental impacts of siting) and on site procedures (such as waste inspection, proper waste handling, incinerator operation and management practices and handling of residues).

Best available techniques (BAT) for waste incineration include appropriate selection of site; waste input and control; techniques for combustion, flue gas, solid residue and effluent treatment.

6.6.3 EU BREF Document on Waste Incineration

EU prepares Best Available Technique Reference (BREF) documents for major polluting technologies, and has also prepared one for waste incineration /7/.

In the introduction to this BREF it is stated:

"*This BREF document does not:*

- *Deal with decisions concerning the selection of incineration as a waste treatment option*
- *Compare waste incineration with other waste treatment options."*

6.6.4 BAT

A BAT is not a juridical binding standard but must seen upon as recommendations or guiding documents.

A generic BAT is intended to apply to the whole sector (i.e. waste incineration, waste gasification and waste pyrolysis of whatever type of waste).

A fundamental BAT stresses the importance of the selecting an installation design (for waste incineration) that is suited to the characteristics of the waste received at the installation in terms of both its physical and chemical characteristics. The BAT (for waste incineration) is fundamental to ensuring the installation may treat the waste received with a minimum of process disturbances – which themselves may give rise to additional environmental impacts. To this end there is also a BAT about the minimisation of planned and unplanned shutdowns.

BAT includes establishing and maintaining quality controls over the waste input. This aims to ensure that the waste characteristics remain suited to the design of the receiving installation. Such quality control procedures are compatible with the application of an environmental management system, which is also considered BAT.

There are several BAT regarding the conditions and management of the storage of incoming wastes prior to their treatment, so that this does not give rise to pollution and odour releases.

Some specific techniques and conditions of storage are noted. A risk based approach that takes into account the properties of the waste concerned is considered BAT. Consideration of the demonstrated ability of some installation designs to very efficiently treat highly heterogeneous wastes (e.g. mixed MSW), and the risks and cross-media effects associated with pre-treatment, results in a conclusion that it is BAT to pre-treat incoming wastes to the degree required to meet the design specification for the receiving installation, noting that to treat wastes beyond this requires balanced consideration of (possibly limited) benefits, operational factors and cross-media effects.

In general the use of the combustion operating conditions specified in Article 6 of Directive 2000/76/EC (WID/6/) are considered to be compatible with BAT. However, the TWG (Technical Working Group) noted, that the use of conditions in excess of these (e.g. higher temperatures) could result in an overall deterioration in environmental performance.

There are several examples of hazardous waste installations that had demonstrated an overall improvement in environmental performance when using lower operational temperatures than the 1,100 ºC specified in WID for certain hazardous wastes.

The general BAT conclusion was that the combustion conditions (e.g. temperature) should be sufficient to achieve the destruction of the waste but, in order to limit potential cross-media impacts, generally not significantly in excess of those conditions.

The provision of auxiliary burner(s) for achieving and maintaining operational conditions is considered to be BAT when waste is being burned.

The recovery of the energy value of the waste is a key environmental issue for the sector, presenting an area where the sector may make a significant positive contribution. Several BATs cover this aspect, dealing with:

- Specific techniques that are considered to be BAT
- The heat transfer efficiencies expected of boilers
- The use of CHP (Combined Heat and Power) - district heating, industrial steam supply and electricity production
- The recovery efficiencies that may be anticipated.

With CHP and steam/heat supply generally offering the greatest opportunity for increasing energy recovery rates, policies affecting the availability of suitable customers for steam/heat generally play a far greater role in determining the efficiency achievable at an installation than the detail of its design.

For mainly policy and economic reasons, electricity generation and supply is often the energy recovery option selected at individual installations. Options for CHP, district heating and industrial steam supply are only well exploited in a few European Member States – generally those that have high heat prices and/or that have adopted particular policies.

The supply of energy for the operation of cooling systems and desalination plants is something that is done, but is in general poorly exploited – such an option may be of particular interest in warmer climate zones, and in general expands the options for the supply of waste derived energy.

The flue-gas treatments applied at waste incineration installations have been developed over many years in order to meet stringent regulatory standards and are now highly technically advanced. Their design and operation are critical to ensure that all emissions to air are well controlled. The BATs that are included:

- Cover the process of selection of FGT (Flue Gas Treatment) systems
- Describe several specific techniques which are considered to be BAT
- Describe the performance levels that are anticipated from the application of BAT.

The performance ranges agreed by the wider TWG resulted in some split views. These were mainly from one Member State and the Environmental NGO, who believed that lower emission values than the ranges agreed by the remainder of the TWG could also be considered to be BAT.

The BAT regarding waste water control includes:

- The in-process recirculation of certain effluents
- The separation of drainage for certain effluents
- The use of on-site effluent treatment for wet scrubber effluents
- BAT associated performance levels for emissions from scrubber effluent treatment
- The use of specific techniques.

The performance ranges agreed by the wider TWG resulted in some split views from one Member State and the Environmental NGO, who believed that lower emission values than the ranges given could also be considered to be BAT.

BAT regarding residue management include:

- A bottom ash burnout TOC level of below 3 %, with typical values falling between 1 and 2 %
- A list of techniques, which when suitably combined may attain these burn-out levels
- The separate management of bottom ash from fly ash and a requirement to assess each stream produced
- The extraction of ferrous and non-ferrous metals from ash for their recovery (where present in ash to sufficient degree to make this viable)
- The treatment of bottom ashes and other residues using certain techniques - to the extent required for them to meet the acceptance criteria at the receiving recovery or disposal site.

In addition to these generic BAT's, more specific BAT's are identified for those sub-sectors of the industry treating mainly the following wastes:

- Municipal wastes
- Pre-treated or selected municipal wastes
- Hazardous wastes
- Sewage sludge
- Clinical waste.

The specific BAT provides, where it has been possible, more detailed BAT conclusions. These conclusions deal with the following waste stream specific issues:

- In-coming waste management, storage and pre-treatment
- Combustion techniques
- Energy recovery performance.

Information exchange
The incineration BREF document is based on several hundred sources of information, and over 7,000 consultation comments supplied by a very large working group. Some of the information was overlapping and therefore, not all of the documents supplied are referenced in the BREF. Both industry and Member States supplied important information.

There was a very good general level of consensus. There was full agreement, and no split views, in relation to the technique related to BAT. There was also generally good consensus upon the quantitative BAT, although the operational emission levels associated with the use of BAT did give rise to some split views, with one Member State and the Environmental NGO recording split views in relation to many of the BAT associated emission levels for releases to both air and water.

6.6.5 Summary - BAT for waste incineration

Best available techniques for waste incineration include appropriate selection of site; waste input and control; techniques for combustion, flue gas, solid residue and effluent treatment.

To achieve best results for environmental protection as a whole it is essential to coordinate the waste incineration process with upstream activities (e.g. waste management techniques) and downstream activities (e.g. disposal of solid residues from waste incineration).

Releases of unintended chemicals from waste incinerators designed and operated according to best available techniques and best environmental practices occur mainly via fly ash, bottom ash and filter cake from wastewater treatment. Therefore it is of major importance to provide for a safe sink of these waste types, for example by pre-treatment and final disposal in dedicated landfills, which are designed and operated according to best available techniques.

With a suitable combination of primary and secondary measures, PCDD/PCDF performance levels in air emissions no higher than 0.1 ng I-TEQ/Nm^3 (at 11% O_2) are associated with best available techniques. It is further noted that under normal operating conditions emissions lower than this level can be achieved with a well designed waste incineration plant.

Best available techniques for discharges of waste water from effluent treatment plants, receiving flue gas treatment scrubber effluents, are associated with PCDD/PCDF concentration levels well below 0.1 ng I-TEQ/l /84/.

6.7 Hazards of Hazardous Waste Incineration Plants

Occupational Health
When working with hazardous waste either as a waste generator or a hazardous waste treatment company there is certain risks that have to be dealt with. Seen from an occupational health of view the special hazards of work with hazardous waste include

- chemical exposure hazards
- fire and explosion hazards
- oxygen deficiency hazards

Besides that all other normal occupational hazards must be kept in mind. They include

- electrical hazards
- especially fall hazards
- heat stress hazards
- noise hazards
- many others

Guidelines for safe handling, training and instructions are beside correct construction of work places the most important guards against occupational health hazards.

Furthermore Contingency Plans for what to do if personnel injuries happen must be in place.

Control of Major Accident Hazards
According to the European legislation establishments where dangerous substances are present in certain well defined quantities shall follow the legislation laid out in the Council directive (with amendments) 96/82/EC of 9 December 1996 on the control of major accident hazards involving substances /107/.

The directive (in annex II) lay out the requirements of data and information to be considered in the required safety report:

1. Information on the management system and on the organization of the establishment with a view to major accident prevention.
2. Presentation of the environment of the establishment

- description of the site and its environment including the geographical location, meteorological, geological, hydrographical conditions and, if necessary, its history;
- identification of installations and other activities of the establishment which could present a major-accident hazard;
- description of areas where a major accident may occur.

3 Description of the installation

- description of the main activities and products of the parts of the establishment which are important from the point of view of safety,
- sources of major-accident risks and conditions under which such a major accident could happen, together with a description of proposed preventive measures;
- description of processes, in particular the operating methods;
- description of dangerous substances: inventory of dangerous substances including
- the identification of dangerous substances: chemical name, CAS number, name according to IUPAC nomenclature
- the maximum quantity of dangerous substances present or likely to be present;
- physical, chemical, toxicological characteristics and indication of the hazards, both immediate and delayed for man and the environment;
- physical and chemical behaviour under normal conditions of use or under foreseeable accidental conditions.

4 Identification and accidental risks analysis and prevention methods

- detailed description of the possible major-accident scenarios and their probability or the conditions under which they occur including a summary of the events which may play a role in triggering each of these scenarios, the causes being internal or external to the installation;
- assessment of the extent and severity of the consequences of identified major accidents;
- description of technical parameters and equipment used for the safety of installations.

5 Measures of protection and intervention to limit the consequences of an accident

- description of the equipment installed in the plant to limit the consequences of major accidents;
- organization of alert and intervention;
- description of mobilizable resources, internal or external;
- summary of elements described above necessary for drawing up the internal emergency plan

A Hazardous Waste Guidelines report that will be worked out in parallel to this report will shortly review procedures that should be in place to reduce the risks associated with accidents and upset operation conditions to an acceptable level.

7 Atmospheric Emission of Pollutants from Incineration

7.1 Generation and destruction of POPs by incineration

Dioxins (PCDD/PCDFs) are formed in most combustion systems. These can include waste incineration (such as MSW, sewage sludge, medical waste, and hazardous wastes), burning of various fuels, such as coal, wood, and petroleum products other high temperature sources such as cement kilns, and poorly controlled combustion sources such as building fires, burning any chlorine compounds. Experimental evidence suggests that temperatures of 500–800 ºC promote PCDD/PCDFs formation, while temperatures greater than 900 ºC destroy PCDD/PCDFs. However, pyrolysis at temperatures greater than 700 ºC causes 99% destruction of PCBs and no PCDD/PCDFs formation /25/.

7.2 Start up and shut down conditions

Incinerators may have dioxin concentration at the stack under steady state conditions at a low level, while those at start-up and shutdown may be higher. This is due to the fact that under start-up and shut down conditions the temperature profile runs through a range that is optimal for dioxin generation /101; 102/. This problem is of course biggest for incineration plants that close down daily like among the approximate 1,900 plants in Japan, that are operated without continuous operation. The furnaces in those plants are started up and shut down daily. Since the combustion is unstable during such periods, there are possibilities for dioxins and other unburnt substances being emitted into the atmosphere /102/.

Preheating the incinerator and initial co-firing with a clean fossil fuel will allow efficient combustion temperatures to be reached more quickly. Wherever possible, however, continuous operation should be the practice of choice. Independent of the operation mode waste should be fed into the combustion system only when the required temperature (e.g. above 850° C) is reached. Upsets can be minimised through periodic inspection and preventive maintenance. Incinerator operators should not feed the waste during filter bypass ("dump stack") operations or during severe combustion upsets /84/.

Most incineration plants in Europe are running on 24 hour basis, and is normally only shut down in connection with maintenance and repair operations 2-3 times a year, thus, providing 7,500-8,500 operating hours annually. Furthermore according to the European Directive on Incineration /6/ then during start-up and shut down or when the temperature of the gas falls below 850 ºC or 1100 ºC as the case may be, the auxiliary burner shall not be fed with fuels which can cause higher emissions than those resulting from the burning of gasoil.

7.2.1 Dioxin emission from other disposal operations

Backyard Burning

Test combustions in barrels were monitored in a scientific examination /21/. The waste fuels used were garden waste, paper, plastic packaging, refuse derived fuel, PVC and electronic scrap. Combustions including PVC and electronic scrap emitted several orders of magnitude more dioxins than the other waste fuels. Emissions from the other fuel were difficult to relate to waste composition. Emission factors of PCDD/F and PCB from the backyard burning ranged from 2.2 to 13,000 ng (WHO-TEQ)/kg. The levels found in ash usually were less than 5 % of the total. For assessment of total emissions of dioxins and PCB from backyard burning of low and moderately contaminated wastes, an emission factor range of 4-72 ng (WHO-TEQ)/kg is suggested. These figures imply that combustion waste in the backyard (or other non controlled places) could contribute substantially to total emissions, even if the amounts of fuel involved are equivalent to just a few tenths of a percent of the amounts combusted in municipal waste incinerators. The amount of toxic PCDD/F and PCB that ends up in the unburned residues and the ashes seems to be of minor importance /21/.

Emission from landfills

In the report "Inventory of Dioxin and Furan Releases" /110/ the release of dioxins and furans from uncontrolled waste burning is summarised in the following table. The calculations indicate that uncontrolled burning of waste may be a major source of emission to air. There is, however, very high uncertainty of the estimates.

Table 5 Potential release of dioxins and furans from uncontrolled burning of waste (2000)

Source category	Activity t/year	Annual emission to air		Annual release to residues
		g I-TEQ/year		g I-TEQ/year
		Medium	Range	Medium
Uncontrolled domestic waste burning	10,000-31,000	6.2	0.5-16	12
Open burning of wood from construction and demolition	860-6,200	0.21	0.02-1.2	0.04
Landfill fires	*	5.5	0.68-10	ND
Total	10,900-37,200	12	1.2-27	12 ?

* The emission from landfill fires was estimated using per capita emission factors based on experience from Sweden.

Options for release reduction

The emission from uncontrolled waste burning will gradually be reduced as more people are connected to a waste collection system. It should be noted that systems of which the fee is dependent on the amount of waste might be an incentive to continued uncontrolled waste burning.

The potential emission from landfill fires is very uncertain, but the experience from other countries indicates that it could be a major source of emission of dioxins and furans to the air. Immediate covering of the waste with soil or other incombustible material reduces the risk of landfill fires.

Reduced use of chlorinated plastics - especially for packaging - may significantly reduce the formation of dioxins by waste burning in households and by landfill fires.

If chlorinated compounds are used for preservation of wood, a reduced use of these compounds will reduce future formation of dioxins and furans from burning of demolition waste.

7.3 Emission of Other Hazardous Substances

Concerning disamenity externalities a report concludes "There is no easy and straightforward answer as to whether incineration or landfill disposal is preferable from the point of view of external effects" /87/.

Incineration may be one significant source of releases of e.g. mercury and other heavy metals unless necessary steps are taken to prevent heavy metals in the waste stream directed to waste incineration. The environmental concerns related to incineration have traditionally been focused on the flue gas as an important source of immediate heavy metal releases to the environment. Most of the emitted heavy metals will be deposited relatively close to the incinerators although a part of the metals - and especially mercury- may be transported over long distances. It should be noted that although only a very small part of the heavy metal content of the waste is emitted to the air, emission from waste incinerators may constitute a significant part of the total air emission from a country. However, as the flue gas cleaning systems are improving to modern standard, disposal of slag and in particular flue gas cleaning residues are becoming major subjects of concern./103/.

7.4 Trends in Dioxin Emission from Incineration in Other Countries

7.4.1 Germany

Due to stringent German and EU regulations, waste incineration plants emissions of dioxins, dust, and heavy metals from waste incinerators in Germany and the EU have been drastically reduced since 1990 even though waste incineration capacity has almost doubled since 1985 (cf. 7).

Table 6 Waste incineration capacity in Germany (Source: Federal Environmental Agency, 2005)

Year	Number	Capacity, in 1,000 tonnes per year (1,000 t/a)
1965	7	718
1970	24	2,829
1975	33	4,582
1980	42	6,343
1985	46	7,877
1990	48	9,200
1995	52	10,870
2000	61	13,999
2005	66	16,900
2007	72	17,800

Total dioxin emissions from all 61 waste incineration plants in Germany in 2000 has dropped to approx. one thousandth of the emission in year 1990 as a consequence of the installation of filter units stipulated by statutory law: from 400 grams (cf. explanation below) to less than 0.5 grams.

In other industries, too, there have been marked declines in dioxin emissions, in metal extraction and processing, for instance, from 740 to 40 grams — approx. one twentieth. The decline, however, has nowhere been as drastic as in the incineration of household waste. The consequence is that whereas in 1990 one third of all dioxin emissions in Germany came from waste incineration plants, for the year 2000 the figure was less than 1%. Chimneys and tiled stoves in private households alone discharge approximately twenty times more dioxin into the environment than waste incineration plants. This is also evident from the fact that in winter airborne dioxin loads are up to five times higher than in summer when heating systems are out of operation. The most extensive dioxin emissions, however, are attributable to metal extraction and processing /8/.

Table 7 Dioxin emission sources in Germany, annual dioxin loads, in grams per toxicity unit (g TU); data for the year 2000 are estimates by the Federal Environmental Agency.

Processes	**Emissions per year in g TU (toxicity units) *1**		
	1990	**1994**	**2000**
Metal extraction and processing	740	220	40
Waste Incineration	400	32	0,5
Power Stations	5	3	3
Industrial Incineration Plants	20	15	<10
Domestic Firing Installations	20	15	<10
Traffic	10	4	<1
Crematoria	4	2	<2
Total emissions, air	1,200	330	<<70

*1 The reference use the unit g TU which probably corresponds to the international unit for dioxin toxicity equivalency: g I-TEQ.

Old incinerators were surely bad for the environment, but today that is not the case anymore as can be seen from the figures below /69/:

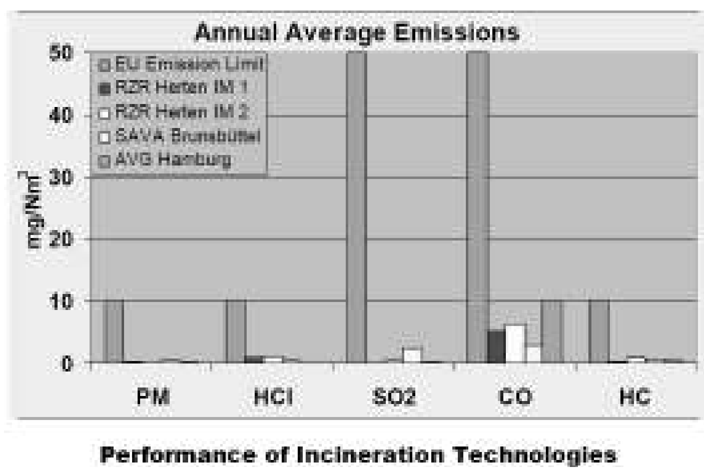
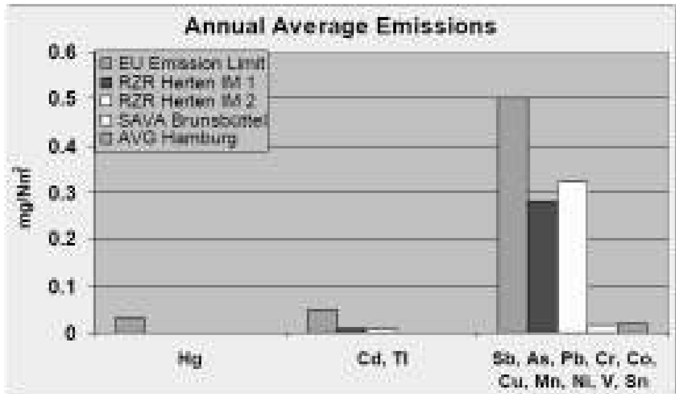
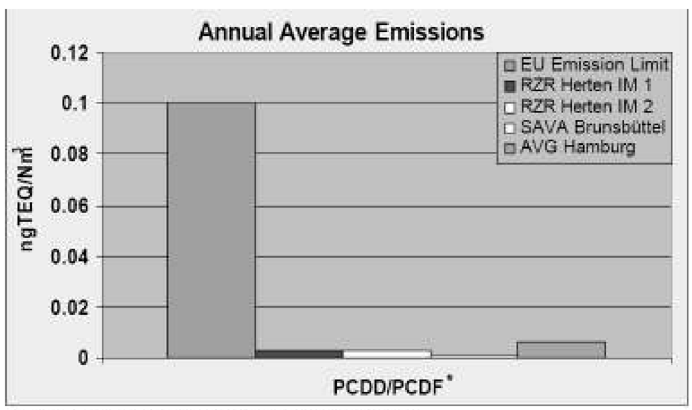


Figure 2: Incineration Emission (diverse)



Performance of Incineration Technologies

Figure 3: Incineration Emission (metals)



* All PCDD/PCDF emission analyses were performed by accredited laboratories

Performance of Incineration Technologies

Figure 4: Incineration Emission PCDD/PCDF

The companies mentioned are

- RZR Herten, Im Emscherbruch 11, 45699 Herten, Germany
- SAVA, Ostertweute 1 - 25541 Brunsbüttel, Germany
- AVG, Borsigstraße 2. D-22113 Hamburg, Germany

Today, more than half of all household waste (55%) in Germany is recycled as bio-waste, waste paper, waste glass, or packaging waste. Since June 1, 2005, untreated waste is no longer landfilled.

7.4.2 Denmark

The most recent Danish dioxin air emission inventory shows that the emission has been reduced from 68.6 g I-TEQ in 1990 to 22.0 g I-TEQ in 2004, or about 68% over a 14 year period. The major emission sources for 1990 were municipal waste incineration plants, steel reclamation and residential wood burning, while in 2004 the major sources had changed to residential wood burning and fires. Fires include landfill fires and fires in buildings and vehicles /20/

A large part of the significant reductions have been achieved in the industrial sector, where emissions have been reduced from 14.67 g I-TEQ in 1990 to 0.17 g I-TEQ in 2004; a reduction of almost 99%. The main reasons for the significant decrease in the emission are stricter emission regulation with required dioxin abatement in e.g. steel and aluminium reclamation industries and the total stop of steel reclamation processes in Denmark from 2002-2004.

Emissions from waste incineration reduced from 32.5 g I-TEQ in 1990 to 2.1 g I-TEQ in 2004; which is approx. 94% in spite of an increase in the amount of waste incinerated of 138% from 1990 to 2004. This was due to installation of dioxin abatement equipment and modification of the combustion process in incineration plants.

The major source in the non-industrial category is combustion of wood in the residential sector and in 2004 it was the most important source of emission, at 8.5 g I-TEQ, or around 40% of the total emission. The emission from wood use has increased by 37% from 1990 to 2004 due to a larger consumption of wood caused by the increase in fuel prices.

In 2004, accidental fires, which are estimated to emit 6.1 g I-TEQ/year, are the second most important source, contributing with around 28% of the total emission /20/.

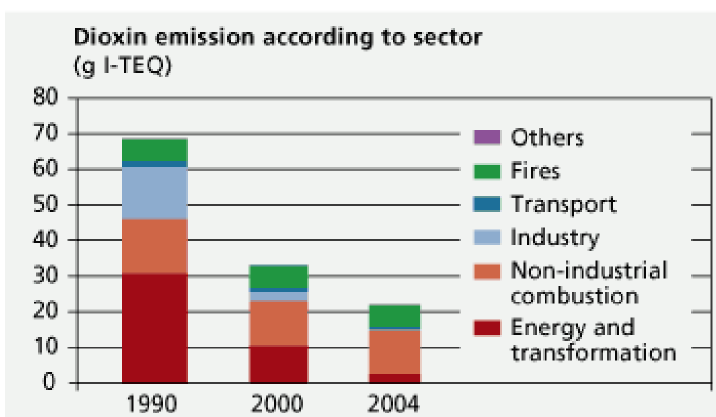


Figure 5: Dioxin emission in 1990, 2000 and 2004, in Denmark distributed according to sector. Total is 68.6 g I-TEQ for 1990, 33.0 g I-TEQ for 2000 and 22.0 g I-TEQ for 2004.

7.4.3 Sweden

The Swedish Association of Waste Management has undertaken a study in 1999-2000 into dioxins and waste incineration in Sweden and it shows that dioxins found in the incineration residues from incineration are solidly fixed /19/. Furthermore, the article inform that from 1985 to 1999 the amount of waste incinerated in Sweden increased by 35 %, but the discharges of mercury and cadmium decreased by 99 %, discharges of lead was reduced from 25,000 kg to 35 kg per year, and zinc from 54,000 kg to 90 kg per year. Emissions of dioxins have been reduced from 90 g per year in 1985 to 3 g per year in 1999 and the amount is still being reduced /19/.

8 Waste-to-Energy (WTE)

Both municipal waste (MW) and hazardous waste (HW) produces energy when incinerated. If this energy is utilised the plant is called a waste-to energy (WTE) plant. The energy productivity - and thereby economics - can be doubled by taking advantage of both the electricity and heat produced. Moreover, the thermal efficiency can be increased by combining natural gas turbines with WTE plants /9/. However, in warm climates, like South Africa, heat cannot be used for domestic and institution heating purposes, but rather for industrial processes, or under certain circumstances heat can be utilised for comfort cooling of large shopping centres, offices etc.

If there was a social ladder of fuels, hydrogen would be at the top followed by methane, fuel oil, coal and wood chips. Municipal solid waste (MSW) would be in the lower middle class and food waste at the bottom. Originally employed to treat wastes, first-generation incinerators were not designed to recover energy. But the increasing cost of fossil fuels and landfilling, coupled with a growing awareness of environmental impacts, prompted a gradual transformation. Modern waste-to-energy (WTE) plants are capital demanding power generators, but they use a renewable fuel that brings in substantial revenues and solves a critcal waste management problem. The global WTE industry processed an estimated 143 million tonnes of municipal waste (MSW) in 2004 (Table 8), which is about 10% of the wastes disposed of in large landfills. The European Union is the biggest user of this technology, followed by Japan and the US.

Table 8 Global waste to energy, 2004

Country/region	Estimated amount combusted in WTE plants (million tonnes)
EU-25	48.8
Japan	40.0
US	26.3
Taiwan	7.0
Singapore	4.0
China	3.0
Switzerland and Norway	3.8
South Korea	1.0
All other	9
Total	**143**

Waste-to-energy is part of the development of the use of renewable resources, the reduction of greenhouse gases and the development of the carbon market as instructed by the Kyoto Protocol/80/.

There are currently (2006) more than 600 incineration plants recovering energy in approximately 35 countries. These plants treat nearly 170 million metric tons of municipal waste. Approximately 70% of this waste is incinerated in Europe, Japan and the United States.

The push to optimize the efficiency of thermal conversion has resulted in significant technological advances. These will become increasingly important as the quantity of wastes increases, fossil fuel prices rise, and global warming becomes an increasingly important issue.

In 2003, there were 409 WTE facilities in Europe, about two-thirds of the world total. A recent study of 97 WTE plants in the EU found that these plants processed a total of 24 million tonnes of MSW annually (2004 data) and generated or co-generated a mix of electricity and thermal energy. The weighted mean calorific value (lower heating value) was 10 MJ/kg, which is 2774 kWh per tonne of MSW combusted.

In contrast to the US, where little use is made of the so-called 'waste' steam, European plants produce more thermal than electrical energy.

Table 9 Results of analysis of 97 plants by Confederation of European Waste-to-Energy Plants (CEWEP[a]) /10/

Energy production	Unit
MSW processed	24.1 million tonnes
Weighted mean thermal energy in MSW	2774 kWh/tonne
Net electricity to grid	302 kWh/tonne
Net thermal energy to district heating,	878 kWh/tonne
Total energy use - assuming equivalence of thermal and electric energy	1180 kWh/tonne
Overall thermal efficiency (1180/2774) - assuming equivalence of thermal and electric energy	42.5%
[a] From data provided by Dr Ella Stengler	

Table 9 assumes that electrical and thermal energies are equivalent. However, the Integrated Pollution and Prevention Control (IPPC) regime in the EU provides weighting factors based on the fact that different amounts of fuel are used to produce electricity and steam. The IPCC (Best Available Technology Reference Document) BREF for waste incineration /7/ specifies that 1 kWh of electricity is equivalent to 2.4 kWh of heat. On this basis, the overall thermal efficiency of the 97 EU plants would be 57.8% (i.e. considerably higher than that shown in Table 9). By the same token, the BREF efficiency of the US plants, which produce an average of 515 kWh of electricity, would be about 44%.

8.1.1 Energy from Hazardous Waste Incineration Plants

The Danish central hazardous waste treatment company - Kommunekemi - receives all kinds of hazardous waste and waste with an environmental impact, except for infectious, explosive and radioactive substances. The waste is delivered in solid or liquid form, packaged and in bulk. The waste arrives at Kommunekemi primarily by road and to a lesser extent by rail and ship. Transportation by railway ceased completely in 2006, (due to National changes of the railway transport of goods).

Figure 6 *Quantity of hazardous waste treated at Kommunekemi*

When the hazardous waste is incinerated, both electricity and district heating are produced for own use and for the local community Nyborg. In the last few years Kommunekemi has covered approximately 80% of Nyborg's consumption of district heating (the town of Nyborg has about 25,000 inhabitants). Until 2002 the entire electricity production was sold to the national grid, and electricity for own consumption was bought back. In the period 2002-2004 it was permitted to use the company's own production of electricity. As a result of a new electricity regulation, being valid as from 2005, Kommunekemi now again sells the entire electricity production to the grid and buys its own consumption of electricity back again /11/.

Table 10 *Energy production from Kommunekemi (The Central Hazardous Waste Treatment Company in Denmark) /11/*

Energy	Unit	2002	2003	2004	2005	2006
Electricity produced	MWh	40,000	49,000	46,000	38,000	46,000
Total electricity consumption	MWh	27,000	30,000	28,000	25,000	27,000
Own consumption of electricity produced	MWh	5,000	13,000	12,000		
Electricity purchased from grid	MWh	22,000	17,000	16,000	25,000	27,000
Electricity sold to the grid	MWh	35,000	36,000	34,000	38,000	46,000
Heat supplied to Nyborg	MWh	150,000	150,000	150,000	150,000	150,000

As can be seen the production of energy as steam for district heating is far the biggest production, and also where the most value for money lies. Sale of energy is very important for the hazardous waste destruction plant to make the necessary profit. If this is not possible the destruction of hazardous waste will be more expensive per ton.

Comment: Although there is a monopoly in the SA on generation of electricity to the grid, that has been so too in Denmark, but has been changed by law. That might also be possible in SA, where there is a particular interest in increasing the supply of power to the grid.

In her presentation at the 2006 North American WTE Conference (NAWTEC 14), Bettina Kamuk, a Danish EfW Specialist, called WTE district heating 'the neglected resource'. The truth of this statement is evident when you compare the 44% BREF thermal energy efficiency of US WTE facilities with the 57.8% BREF thermal efficiency of the 97 EU WTEs./9/

According to Kamuk, the energy efficiencies obtained in Danish WTE plants are much higher than those found in the CEWEP study of 97 WTE facilities (Table 5). On average, Danish WTEs provide about 450 kWh of electrical energy and 1970 kWh of thermal energy per tonne of MSW combusted corresponding to a an overall thermal efficiency of 2430/2774 = 87,5 %. Denmark has a population of 5.4 million and has 31 WTE facilities distributed nationwide.

The conventional wisdom of 'economies of scale' is defied in Denmark because its relatively small WTE plants are sited as close as possible to the communities they serve in order to allow the 'waste' steam to be used for district heating. This also reduces the waste transport distance. Kamuk reported that Danish WTE plants derive US$60/tonne of MSW from the sale of thermal energy and US$40/tonne from the sale of electricity. The electricity and thermal energy revenues allow citizens to pay considerably lower disposal fees to WTE facilities compared with the US. /9/

WTE plants in the US generate 13.5 billion kWh of electricity. Japan is a big user of WTE, but most of its WTE facilities are relatively small, do not provide much district heating and use electricity for vitrifying the WTE ash. Therefore, on the average, they generate an estimated 250 kWh per tonne for a total of 10 billion kWh of electricity.

The rest of the global WTE plants generate an estimated 7 billion kWh of electricity. This brings the global energy generation to about 46 billion kWh of electricity and the same amount of thermal energy.

To appreciate the contribution of the global WTE industry to the conservation of fossil fuels, it is worth pointing out that the energy it generates reduces the use of coal by about 35 million tonnes /9/.

This environmental benefit would be increased five-fold if the thermal efficiency of the plants in the CEWEP study was achieved globally. It would increase much more if the MSW now going to landfills was combusted in thermally efficient WTE facilities.

If the contribution of landfill non-captured methane to greenhouse gas emissions is also considered, it is clear that a gradual move from landfill to WTE is one of the low-hanging fruits in reducing global warming.

8.1.2 Possible Waste to Energy Production from Hazardous Waste Incineration in South Africa

The annual general of hazardous waste in the Republic of South Africa is in the range of 1.4 - 2.0 million tons / 34; 37/. It is estimated that Republic of South Africa has at least 80,000[2] tons of organic hazardous waste /38/ and about 15 million to 18 million tons of municipal waste /37; 38/[3].

If this number is calculated in another way based on the amounts from Erkhurleni 2003/2004 /108/ where all the municipal waste is weighed then in 2003/2004 the population of 1,234,518 generated 2,327,004 tons of municipal waste corresponding to 530 kg/capital/annum. If there were 44 million inhabitants in 2003/2004 in South Africa, then 530 kg/capita/annum corresponds to 23 million tons then the 15-18 million tons (~ 400 kg/capita/annum) do not seem so wrong.

In South Africa where there is no need for district heating, that means that a possible WTE-plant optimal should be place next to an industry that might buy steam for use in the plant processes.

On the other hand district cooling could be an option in the near future. In a recent article by Y. Shimodaet al. /106/ the aim is to verify the advantages of district heating and cooling (DHC) systems in terms of energy efficiency. From the measurement data, the parameters that characterize the energy efficiency of a heating/cooling plant are identified for DHC and an individual building. A simulation model that considers the difference in these parameters is developed. This model examines both the advantages and disadvantages of DHC systems and the effect of each parameter. The results show that the energy efficiency for cooling in DHC systems is superior to that in the case of individual cooling systems because of the “concentration effect” and “grade of operation”. Furthermore, it should be considered that traditional comfort cooling is operating on fossil fuel derived electricity, whereas the district cooling would operate on a "renewable" and non-fossil fuel, namely waste, which in terms of global carbon emissions and environmental sustainability is much more preferable.

[2] calculated as sum of class 3 and class 4 waste in table 9.2 under year 2000 in ref. /38/

[3] (calculated as 6.2 million tons/15 mill. inhab.in Gauteng x 44 mill. inhab. = 18 mill.ton)

9 The Economics of Hazardous Waste Incineration

Cost of hazardous waste incineration is of course in important factor in the considerations if hazardous waste shall be incinerated or not. Here only a short review is provided as a thorough review is beyond the scope of the TOR for this assignment.

Companies producing hazardous wastes are becoming increasingly concerned about the safety and cost of storage and the responsibilities of transporting and disposing of them at landfill sites. In addition to paying for disposal fees and shipments costs, generators of hazardous waste can potentially be held liable for the cost of cleanup if the waste disposal site contaminates the environment after closure or abandonment.

Furthermore, cost of disposing at hazardous waste landfill, may be comparable to e.g. the cost of hazardous waste incineration. Hence, with a monopoly situation costs can be equally high. Price-setting of the environmental liabilities and cost of aftercare at a hazardous waste landfill may be underestimated, It should in this regard be noted that ultimately the public and the government budget always carries the residual risk for hazardous waste landfills. However, that risk is rarely priced into the gate fees at such - privately driven - hazardous waste landfills.

An alternative to storage and landfill disposal is incineration. However, entry of hazardous waste incineration to the SA market is difficult, as there is no surety that the hazardous waste will actually arrive at the gate, due to lack of regulatory and enforcement measures. Incineration costs however are not low either, but they have the advantage of being known and final. Incineration costs include among others capital cost, operating cost, maintenance cost, and cost of externalities.

9.1 Direct Costs of Hazardous Waste Incineration

According to a World Bank workshop in 2004 /69/, the following cost may be found for hazardous waste incineration:

Cost of High Temperature Incineration for Hazardous Waste:

- Capital cost: USD 35 - 50 million (based on a 6 t/h throughput per unit for a new rotary kiln type facility
- Operating cost: Highly dependent on heating value, ash, halogen and sulphur content of the waste
- Maintenance cost: Typically 3-5 % of capital investment cost

Prices for High Temperature Incineration of Hazardous Waste:

- High heating value liquids: About 20-150 USD per metric ton
- Medium ash, medium heating value liquids, sludges and solids: About 250 - 500 USD per metric ton
- High halogen solids (e.g. pesticides): About 1000 to 1500 USD per metric tons

9.2 Economic Valuation of Environmental Externalities

Waste incineration is associated with local environmental nuisances such as plant noise, smell, visual intrusion and traffic. Only very few studies have been undertaken that investigate disamenity effects associated with incineration making valuation of disamenity troublesome. However, a number of studies of landfill disamenity effects have been carried out. While there are differences in the types of "aesthetic attributes" and disamenities associated with living close to an incinerator and close to a landfill, there are also obvious similarities.

Until this point in time, no European studies have been undertaken to investigate the disamenity costs associated with incineration of waste and only very few international studies touching the subject exist. Hence, only a single result of the disamenity costs associated with incineration of waste was found. Due to the origin of the studies, it is not justified to use the results in a European context. Therefore, currently it is not possible to cite any disamenity cost figure for incineration.

Incineration of waste is not only associated with external costs, but frequently also with both external and internal benefits. For example and most importantly, incineration can be accompanied by recovery of energy /87/.

9.3 OECD - Addressing the Economics of Waste Incineration

The Secretariat of the Basel Convention estimates the global total of hazardous wastes generated to be over 400mt per annum. Acknowledging the general lack of knowledge and reliable data in this field, and the consequent impediments for effective policy formulation and monitoring, the OECD Council decided that Member countries would co-operate in the collection of harmonised data on waste imports and exports and to make these data publicly available. Information is reported by OECD countries to the Waste Management Policy Group.

Calculations show that as a very rough estimate, for OECD countries with a relatively strong chemical sector, about 120 kg of hazardous wastes are generated per capita. For other OECD countries, about 50 kg of hazardous wastes are generated per capita /104/.

OECD has published a compilation of papers "Addressing the Economics of Waste" in 2004 /14/. Soizick de Tilly's paper describes trends in waste generation and waste policies over the last decade or so, focusing in particular on municipal waste, i.e. waste from households and smaller enterprises /14/. According to OECD statistics, municipal waste generation increased by 14 % between 1990 and 2000, from 530 to 605 million tonnes in the OECD countries. Measured per capita, municipal waste generation increased from 509 to 540 kg, a rise of 6 %, while total population in the area increased 8 % over this period.

The paper explains that the increase in the amounts of municipal waste is the net impact of several, sometimes conflicting "drivers", like economic growth; a growing number of households; smaller average household size; growing urbanisation (with better waste collection services in urban than rural areas); changing consumption patterns and changing socio-cultural habits.

De Tilly illustrates that although most municipal waste is still disposed of in landfills, this method of waste management is less and less dominant: Municipal waste landfilling increased by 2% between 1995 and 2000, while municipal waste generation increased by 10%. Incineration of municipal waste with energy recovery, and composting of moist organic waste, is becoming increasingly common.

However, major differences between different countries and regions are described in the paper. There is also a broad trend towards increased recycling. Recycling rates differ according to the type of material, surpassing 80 % for metals, 35-40 % for glass, 40-55 % for paper and cardboard. Recycling rates differ also considerably from one country to another: in Ireland, for example, 10 % of paper and cardboard is recycled whereas the figure for Germany is 70 %.

Municipal waste constitutes only a minor share of total waste amounts. According to The European Economic Association (EEA), manufacturing waste constituted 26 % of the total waste amount in EEA countries in the period 1992-1997, while mining and quarrying waste constituted 29 %, construction and demolition waste 22 % and municipal waste 14 %. It should, however, be emphasised that these numbers are uncertain.

De Tilly finds that broadly speaking, environmental impacts of waste management in the OECD countries have diminished over the last ten years, due to extensive regulation, especially concerning landfills and standards for incinerator emissions and the development of highly efficient technologies, such as for controlling dioxin emissions from incinerators. However, in many cases, current disposal capacities are seen as insufficient.

The paper also states that emission regulations and standards are often not complied with, and that poor waste management in the past e.g. have led to long-term contamination of soil and groundwater. Local authorities set waste management charges that do not reflect environmental externalities and fail to provide a coherent basis for the use of the different potential methods of waste management /14/.

9.4 Environmental and Socioeconomic analysis of Incineration vs. Recycling for Organic Household Waste

The Danish Environmental Protection Agency has carried out a cost benefit analysis of the consequences of increasing recycling of organic household waste /12/. In the cost benefit analysis both the economic consequences for the affected parties and the welfare-economic consequences for the society as a whole have been investigated. In the welfare-economic analysis the value of the environmental effects has been included.

The analysis shows that it is more expensive for the society to recycle source separated organic household waste by anaerobic digestion or central composting than by incineration. Incineration is the cheapest solution for the society, while central composting is the most expensive.

The total welfare-economic additional cost, compared to present treatment (incineration), of recycling about half of the organic household waste, equal to 300,000 tonnes, by anaerobic digestion is DKK 230 mill (€ 31 mill) per year. The additional cost of recycling 300,000 tons by central composting is DKK 270 mill (€ 36 mill) per year.

Furthermore, technical studies have shown that there are only small environmental benefits connected with anaerobic digestion of organic household waste compared with incineration of the waste.

Almost all of the environmental effects, that have been quantified, have also been valued and they have been included in the welfare-economic analysis.

The analysis shows that the value of the environmental effects only accounts for 5 – 10 per cent of the net cost.

In addition, there are a number of positive environmental effects connected with recycling, but it has not been possible to include in the analysis, e.g. improved soil quality, less use of pesticides, and a better quality of the bottom ash. It is assessed that the inclusion of these effects would not affect the results of the analysis.

The primary reason, for recycling being more expensive than incineration is the necessary, but cost-intensive, dual collection of the household waste. Treatment itself is cheaper for recycling compared to incinerating. In the analysis the extra cost of the dual collection is calculated on the basis of full-scale experiments/tests in several municipalities.

The extra cost is about DKK 150 (€ 20) per household per year for single family houses and about DKK 110 (€ 14.7) per household per year for apartments. The extra cost must be below DKK 50 (€ 6.7) per household per year for single family houses and below DKK 20 (€ 2.7) per household per year for apartments in order to make anaerobic digestion more attractive than incineration. For central composting the corresponding costs should be below DKK 30 (€ 4) per household for single family houses and below DKK 10 (€ 1.3) per household for apartments. The extra cost should therefore be reduced by 60% for single family houses and by 83% for apartments, under the assumptions in the analysis, in order to change the conclusions

Sensitivity analyses show that the conclusions are not sensitive to changes in the assumptions of the analysis. This means that the ranking of the three alternatives – incineration, anaerobic digestion and composting – seems rather stable and not very sensitive to changes. Only a so-called optimistic recycling scenario, based on the most optimistic technical assumptions, is able to change the ranking of recycling and incineration, but this only applies for single family houses, and not for apartments /12/.

9.5 Hazardous Waste incineration in Nigeria and Angola

In 2004 both Angola and Nigeria implemented the smaller hazardous waste incinerators from Soil Recovery, Denmark.

The plants are designed for 350 kg of hazardous waste per hour, but may run up to about 7-800 kg /hour. In mean the plant treats about 500 kg/hour or about 3-4000 tons/year.

The plant in Angola has been running stable for more than 3 years. There have been problems with loss of 1 or 2 lining stones in the rotary kiln, but otherwise the incinerator has worked well. The capacity has though been less than in Nigeria.

The waste stems from the off-shore industry and consists mainly of crude oil contaminated wastes, PCB, all kinds of chemicals from oil related industry, waste oils, sludges, wax etc.

The plants are run by one operator at day shifts, one operator at night shifts, three handymen working shift (one day, one night and one on off), same for the forklift driver, and the same for the mechanics. In all 11 persons are employed.

The prices for treating the waste is approximately 250 $/ton to 500 $/ton. The energy produced is utilized neither in Nigeria nor in Angola /83/.

Figure 7: Small rotary kiln in Nigeria

9.6 Taxation Systems

9.6.1 Municipal Waste Tax in Norway

Taxation is used in many countries to manage and direct the waste to the wanted treatment option. In Norway they experiment with a special form of taxation.

As a second case study, the paper by Torhild H. Martinsen and Erik Vassnes presents the Norwegian tax on final waste treatment that was introduced in 1999 /14/. The objective of the tax is to price the environmental damage caused by final waste treatment. The tax was expected to contribute to an increase in source separation and recycling and thus reduce the amount of residual waste.

When the tax was introduced, it was levied per tonne of waste delivered to landfills and incineration plants. In order to make the tax better reflect the environmental harm done, the tax on landfills has been differentiated, with a tax rate of NOK 327 (about 40 €) per tonne waste delivered to a landfill with a high environmental standard, and NOK 427 (about 52.5 €) per tonne waste delivered to a landfill with a low environmental standard. The tax rate on waste delivered to incineration plants varies at present on the degree of utilisation of energy produced during incineration. If none of the energy is used, the tax rate equals that of waste delivered to landfills with a high environmental standard.

Since the introduction of the tax, significant changes in the handling of waste have taken place in Norway. In 1998, 43 % of household waste was landfilled, while 33 % was recycled and 23 % incinerated. In 2002, the share of landfilling had dropped to 24 %, while those of recycling and incineration had increased to 45 % and 31 %, respectively.

To obtain a correct pricing of the environmental costs of waste treatment, an emissions tax would be preferable to a tax on the amounts delivered to landfills or incinerators. However, an emissions tax requires measuring of the actual emissions. It is not yet possible to measure emissions from landfills, but a separate tax on emissions from incineration of waste has now been designed, with tax rates based on estimates of the economic value of environmental damages caused by emissions from incinerators. This emissions tax will give incentives to reduce emissions from waste, i.a. by improving the flue gas cleaning.

According to the paper more than half (approximately 21 € out of a total of 40 €) of the total estimated environmental cost of incinerating an average tonne of waste, stems from emissions of hazardous chemicals. Of particular importance are emissions of chrome and manganese, with estimated values of 7.9 € and 6.6 € per tonne waste, respectively.

Despite a very high cost per unit emitted (almost 283,000 € per gram) used in the estimation, dioxins "only" contribute 2.9 € per tonne waste. Emissions of non-greenhouse gases (e.g. NOx, SO_2, VOC) contribute about 8 € all together to the total estimated economic value of the environmental damages from incineration, dust adds about 5.3 € and greenhouse gas emissions about 4.8 €. The taxation will be based on continuous measurements for the non-greenhouse gases and for dust, and two measurements per year for heavy metals and dioxins.

For greenhouse gases, the situation is more complicated: While incineration of waste fractions that contain plastics or carbon from other fossil matter cause net emissions of CO_2, incineration of biological waste (e.g. plant rests, wood, paper) does not cause *net* climate gas emissions. Even if one *can* measure *total* CO_2 emissions directly, it would only be relevant to tax the *net* CO_2 emissions. As it anyway is not possible to measure the net emissions directly, it has been decided to base the CO_2 component of the tax on the *weight of the waste* incinerated. Plants that can prove that they do not burn any fossil waste will be exempted from the CO_2 component.

The measurement obligations described here are based on requirements already contained in the directive 2000/76/EC of the European Parliament and of the Council on the incineration of waste, and thus represents few additional burdens on the plants. The Norwegian Parliament has decided to replace the differentiation of the tax on incineration plants according to the degree of utilisation of energy with a subsidy dependent on the amount of energy produced from waste. This subsidy will also cover production of energy from landfills/14/.

10 Advantages and Drawbacks of Waste Incineration

10.1 Claimed advantages

Claimed advantages of incineration by the industry includes

- the reduction of landfill space needed,
- length of useful life of the incineration plant,
- safe disposal of some toxic pollutants,
- production of energy from the burning of waste (as CHP has been used in European cities),
- ability to reclaim metals such as aluminium, and
- the waste is receiving a final treatment immediately and not stored in landfills, possibly causing problems for future generations
- the usefulness of the residue e.g. for road building.

Incineration has in the past has been justifiably criticised. However, these criticisms have led to an undeniable improvement in the technology, regulation and processes used, making incineration safer and more environmentally friendly. It also seems to be true that a waste incinerator designed, built and operated to the new standards (which could also produce energy) would be much better at controlling pollution than a site built primarily to produce energy.

Sheffield University Waste Incineration Centre (SUWIC) is central to the Engineering Research Network funded by the UK Engineering & Physical Sciences Research Council (EPSRC). They say that although it is increasingly agreed in the clean technology community that the thermal treatment of the waste materials represents one of the best overall environmental options, this view is not generally accepted by the public because of the fear of the unknown effects of dioxins/furans. The network aims to place industrial expertise in this field on a firm and rigorously based foundation /29/.

10.2 Generation and Emission of Pollutants

In the Ground-Works report "Incineration and POPs releases in South Africa" /72/ the following is stated:

"There is currently a nationwide push by the cement industries in South Africa to burn hazardous waste (including obsolete chemicals) in cement kilns (incinerators) in South and Southern Africa.

Some of the types of hazardous and non-hazardous wastes currently proposed to be burnt in cement kilns include industrial solid, liquid and sludge waste, solvents, oily sludge, varnishes, carbon black, plastic and rubber waste, textile waste, contaminated packaging materials and plastic drums, waste oils, paint sludge, glues, sewage sludge's, tars, tyres, paper waste, wood waste, paper sludge, plastics and spent solvents, solvents and waste containing solvents, *waste from petroleum refinery, oily liquid waste, waste paint, varnish, glue, mastic, ink, machining sludge with hydrocarbons, grease and lubricants, waste from synthesising or other organic chemical operations and rejects and spoils of plastic materials, rubber, textiles, wood shavings and sawdust."*

The big problem for South Africa is that today all these hazardous waste types are disposed of either in legal or illegal dumpsites. They are not being treated and will therefore pose a problem in all years to follow.

In the GroundWork report it is said:

"The disposal of hazardous waste by incineration is known to result in the release of toxic emissions including by-products of POPs such as dioxin and furan, and heavy metals into the air, water and land leading to contamination of the environment."

It is difficult to understand why GroundWorks do not discriminate between good and bad incineration.

First - the concentration of the dangerous chemicals emitted to the air before and after an incineration is huge, so the dangerous effect of the chemicals are reduced hundred thousand folds or more by incineration alone. The accusations that incineration creates more problems than the original chemicals are not true. Old incinerators were surely bad for the environment, but today that is not anymore the case see /69/.

10.2.1 Incineration contra recycling

In the article "Incineration: not a solution but a problem" Greenpeace argues against incineration. According to this article the incinerators are the largest source of toxic pollutants - such as lead, mercury and dioxins - to the environment/17/. According to this article recovery, recycling and composting is the way to go (*which is in line with the recommendations from authorities in most countries*), still the article does not argue about the problems arising when hazardous waste can not be recovered, recycled or composted.

However, the article is correct in mentioning the problems about emission which has often been a problem in the past but which is not the case anymore with the introduction of increasingly stricter emission standards in the 80'ies, 90'ies and the latest EU emission standard from the year 2000. For example, before 1990 the largest emitter of dioxin to the Danish society was waste incineration /18/. However, this is no longer the case as the emissions since 1990 has been reduced significantly and whilst the total annual emissions of dioxins have been reduced, incineration plants now contribute with a very modest part of the total annual emissions/30/.

In a paper from Australia, the main argument against high temperature incineration is that if incineration is forbidden then it will force companies to store liquid solvents on their premises, which will cost them a lot, and force them to investigate alternative production methods and alternative destruction methods /15/.

The main argument that companies in that case will spent more money in trying to avoid waste production is of course correct, and often waste reduction can be achieved. However all experience show that zero waste from production companies is very seldom possible.

However, if a company has a given production they normally only very slowly can change their production, and often it is not possible. In any case it is just environmental incorrect to store big amounts of solvents (and other types of hazardous waste) on their premises due to fire hazards, seepage and other accidents. Furthermore, companies have their strength in the production of one (or more) products, but they are normally not interested in developing waste treatment methods. Therefore a better approach would be to let the waste generator pay for proper incineration of their waste. If costs of waste treatment are an incentive, it would still be so, but in a much more environmentally correct way.

In the UK millions of tonnes of domestic waste are produced. Many people assume it has been destroyed, but according to NAIL (Nottingham against incineration and landfill) it is one of the fundamental principles of science that matter can never be destroyed; it can only be transformed. Incinerators do not destroy waste. They simply turn it into ash, gases and particulate matter. Our rubbish still exists. We may see less of it. But we're breathing it in instead /16/.

According to NAIL, chemicals are emitted from their chimney-stacks, in grate (bottom ash) and in water discharged to the sewerage system. The heat of the incinerator furnace vaporises some of the hazardous heavy metals - such as mercury, lead, cadmium, chromium and tin - found in household waste. And it causes chemical reactions, producing many new toxic chemicals, such as dioxins, polychlorinated biphenyls (PCBs), polychlorinated naphthalene's, chlorinated benzenes, polyaromatic hydrocarbons (PAHs). Other pollutants, Claim NAIL, such as sulphur dioxide and nitrogen oxides, are also released in huge quantities.

NAIL claims that the monitoring regime for incinerators is inadequate. It is entirely based on self-reporting and the range of measured pollutants is too narrow, less than half a dozen substances are continually monitored. The most toxic chemicals are only checked a few times a year, which is likely to miss any peaks production/16/.

Maybe in some places the monitoring regime for incinerators is inadequate, but self-reporting has been shown in many countries to be one of the best ways to raise the environmental awareness among professional waste treatment companies. When a proper followed system is build, then the use of incineration is much less polluting than the landfill options that often is used around the world today. The main problem is that 1 ton of solvent in a landfill is much more harmful than kg- amounts of harmful organic residues produced by incineration. A big part of the organic solvents will evaporate as Volatile Organic Components (VOC). VOC's must be limited in order to prevent or reduce air pollution resulting from the contribution of VOCs to the formation of tropospheric ozone /62/.

Today - in the EU - incineration is seen as BAT (Best Available Technique) for waste treatment.

10.3 Recycling

One of the arguments against incineration is that it hampers the introduction and implementation of recycling. However, recycling is a huge task and recycling is generally lower in countries without incineration than in countries with incineration of the municipal and hazardous waste. It may look as if the huge effort that's needed to get collection running and treatment put in schemes increase the recycling if also the difficult products can be incinerated in the same time. There will always be some fractions that are more or less impossible to recycle.

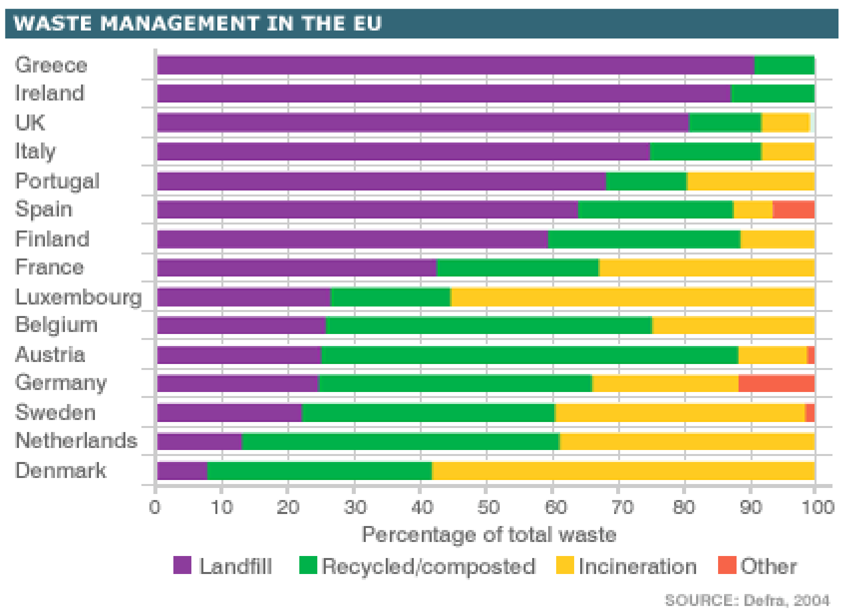


Figure 8: Waste Management in the EU /63/

As can be seen from
Figure 8 it is not so, that if you landfill much then you have much recycling. In fact it looks very much so that if you have a waste treatment system as incineration, it does not reduce recycling.

This may be shown again in another way as in

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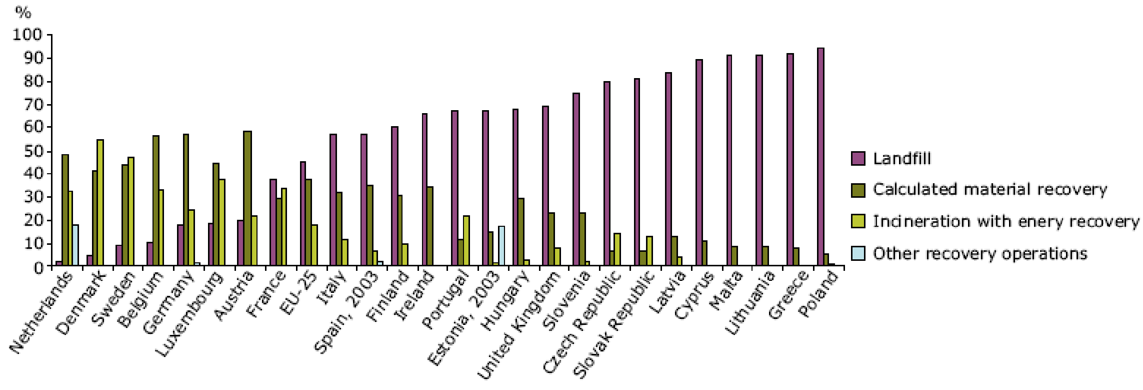

Note: To provide an estimate of material recovery, the above figure uses the residual of municipal waste generated minus municipal waste landfilled and incinerated (with minor adjustments). Thus defined, material recovery covers recycling, composting and other types of recovery operations (except incineration with energy recovery). The category 'other' covers sorting operations for the Netherlands, and differences between Eurostat data and national statistics for Germany, Spain and Estonia.

Source: Eurostat Structural Indicators on municipal waste generated, incinerated and landfilled, supplemented with national statistics: Statistisches Bundesamt (2006), Centraal Bureau voor de Statistiek (2007), Ministerio de Medio Ambiente (2005), EEIC (2005).

Figure 9: Use of landfilling, incineration and material recovery as treatment options in the EU in 2004 /105/.

As can be seen from Figure 9 the calculated material recovery is not lowered when the incineration percentage is high. On the other hand it looks like if the landfilling part is big then the material recovery part is low.

In a report from 2005 /77/ we can see the status of EU-countries in implementing the landfill directive and an explanation, which may clarify further Figure 8:

Austria has already reached the last reduction target of Article 5 (Waste going to landfills must be reduced to 35 %). Austria has a legal obligation to collect biodegradable waste separately, which is then composted. Packaging waste must also be separately collected and reused or recovered. In larger construction projects the biodegradable waste must be separated. Landfills may only accept waste which has been pre-treated by incineration in order to attain a TOC of less than 5% or that has undergone biological mechanical treatment.

Belgium submitted regional strategies for the Walloon Region and the Flemish Region. No strategy was submitted for the Brussels Region.

The ***Flemish Region*** already exceeds the last reduction target set by Article 5. The Flemish Waste Management Plan provides for further reductions by banning the landfilling of some wastes, such as unsorted household waste, waste collected for recovery and the combustible fraction (with a TOC of more than 6%).

The ***Walloon Region*** plans to reach the targets by setting targets for the reduction of the generation of municipal waste, for the overall recovery of waste and for recycling. Separate collection of organic waste is foreseen on a voluntary basis. New installations for biomethanation, composting and energy recovery should be created.

Denmark has already reached the last reduction target by banning the landfilling of all waste suitable for incineration.

France already largely respects the targets for 2006 and 2009. Since 2002 only 'final waste', that means waste that can not be treated anymore under the present technical and economic conditions may be accepted in landfills. Paper recycling will increase due to the new targets for recovery of packaging waste. The development of separate collection of biodegradable waste is included in many regional waste management plans. Several regional waste management plans provide new incineration plants.

Germany will fulfil the last reduction target in 2005, not only for municipal waste but for all biodegradable waste. German law provides a general separate collection obligation. Biodegradable municipal waste is separately collected and composted. Waste wood may not be landfilled. Packaging waste is collected and recovered to a high extent, the recovery quota nearing its limit. By 1 June 2005 landfills may only accept municipal waste that has been incinerated (TOC of 3%) or that has undergone mechanical biological treatment (TOC of 18%).

Italy already fulfils the target for 2006. Through economic measures, including an ecotax, the price of landfilling will increase, which will lead to a reduction of landfilling. An increase in separate collection of organic waste is foreseen in particular in the southern regions. New incineration installations will be constructed. There are landfill bans for high and medium risk animal by-products and organic healthcare waste.

Greece will postpone the attainment of the targets by four years. Greece has set up a system for the separate collection and recovery of packaging waste. Biomechanical treatment plants and/or energy recovery plants will be constructed where economically and technically feasible. The regional plans will have to be updated and include the measures to reach the reduction targets set in the national plan. Operators of new and existing landfills must select a solution for the pre-treatment of the waste.

Luxembourg has set up different systems for the separate collection of kitchen waste, green waste and paper and wood. The two landfills for municipal waste are equipped with a separate collection station and have installations for the pre-treatment of the waste (shredding, sorting, homogenisation, organic stabilisation).

The Netherlands already fulfil the last reduction target. Most of the municipal waste is incinerated. Home composting is encouraged. Targets are set for the separate collection of organic waste. The landfilling of separately collected biodegradable waste is banned. Incineration of waste outside of installations is prohibited. For the treatment of separately collected biodegradable waste composting and fermentation are the preferred options.

Portugal has set targets for the increase of separate collection of food and garden waste initially only from the main source such as restaurants, canteens, supermarkets and at a later stage also from private households. In future only separately collected biodegradable waste will be composted. Back yard composting will be promoted. The construction of several new biological treatment plants is foreseen. A third incineration plant will be built and the expansion of existing incinerators is under consideration. Objectives for the recycling of paper packaging have been set. The increase of landfill fees and the introduction of phased landfill restrictions are under consideration.

Sweden has banned the landfilling of combustible waste and organic waste. Exemptions can be granted if there is a lack of capacity. The amount of waste for which an exemption is granted is decreasing. Most of the waste is incinerated. Biological treatment is growing.

The **United Kingdom** makes use of the possibility of the Landfill Directive to postpone the attainment of the targets by four years. In order to attain the targets the waste disposal authorities will be allocated allowances for the landfilling of biodegradable waste. Recovery and recycling targets are set for packaging waste. These allowances are tradable. Regional strategies have been developed for England, Scotland, Wales, Northern Ireland and Gibraltar.

Mixed Waste Recycling
In the report "Evaluation of Waste Incineration as Treatment and Energy Recovery Method from an Environmental Point of View" PROFU, 2004 /68/ it is examined whether mixed waste shall be recycled, incinerated or treated biologically (e.g. paper, plastics, compostable material). The main conclusions of the report are:

- Landfilling is still the main option in Europe. It is also clearly the worst environmental option according to this study

- Material recycling, waste incineration and biological treatment are complementary options that all need to be expanded in order to replace landfilling

- To reach the best environmental results for material recycling and biological treatment of organic combustible material, waste incineration is necessary for treating residues arising during pre-treatment and processing at the material recycling facilities and the biological treatment plants.

- Due to different local conditions and opportunities for development, the distribution of waste being treated by material recycling, waste incineration and biological treatment must be allowed to vary.

- Regional differences will lead to different distributions being optimal for different regions in Europe.

- Material recycling generally leads to lower environmental impact than incineration. However, this conclusion is valid only if the material recycling is based on well source-separated and clean material fractions that can be efficiently recycled and replace virgin production of the original product. Nevertheless, for some paper products incineration could lead to lower environmental impact regarding ground water pollution, photooxidants and toxicity. The same goes for eutrophication and toxicity in the case of plastics.

- For easily biodegradable waste, the difference between waste incineration and anaerobic digestion are small for the studied impact categories. Regarding acidification and eutrophication, anaerobic digestion might be a better alternative according to the results of these studies. For toxicity, an advantage for incineration could be observed.

- In comparison to composting of easily biodegradable waste, waste incineration is generally preferable in the studies regarding ground water pollution, acidification, and photooxidants. For eutrophication, composting is a better alternative in the studies.

- With few exceptions, incineration leads to a lower environmental impact than landfilling in all the examined studies.

Recycling - South Africa and others

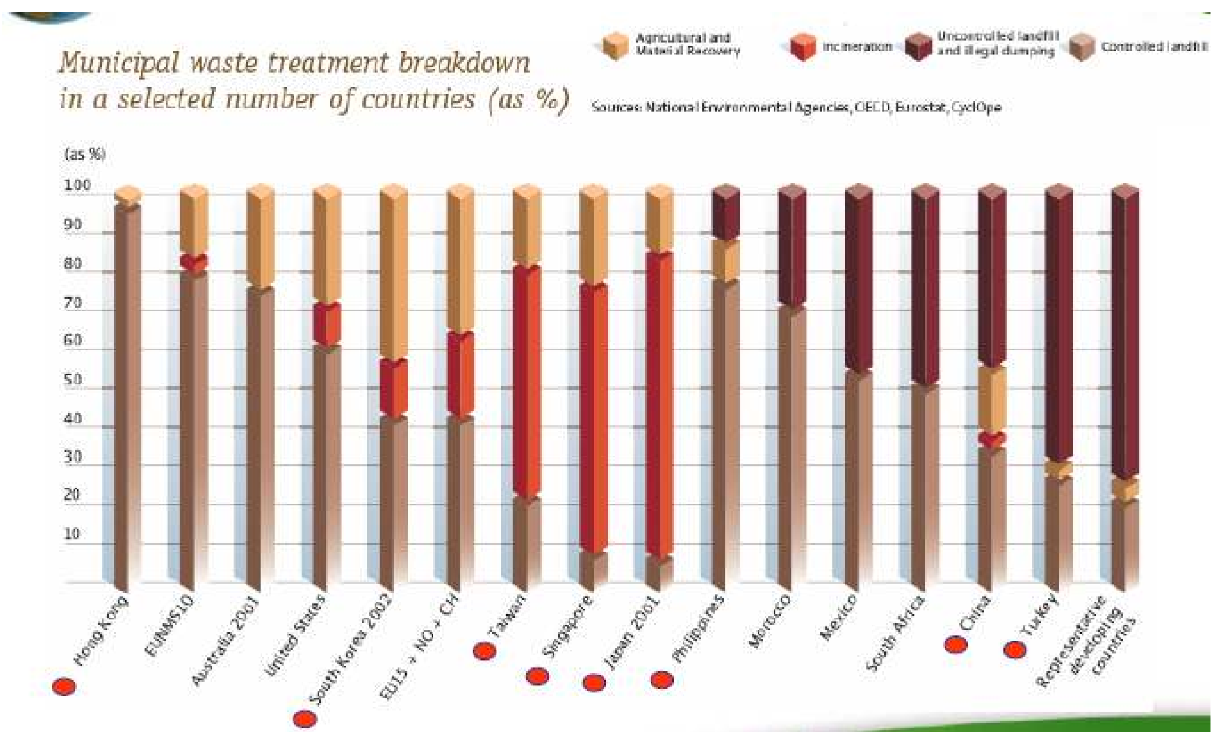

Figure 10: Municipal waste treatment/71/

As can be seen from this figure the amount of waste being recycled in South Africa seems negligible. What can be seen furthermore is that all countries have landfills. However it is important what types of waste is being disposed of at the landfills.

10.4 Associated Health Effects

The US Government set up the National Research Council's Committee on Health Effects of Waste Incineration, to assess relationships between waste incineration and human health and to consider specific issues related to the incineration of hazardous waste, municipal solid waste, and medical waste. The committee was asked to consider various designs, siting, and operating conditions at waste-incineration facilities with respect to releases. Few epidemiologic studies have attempted to assess whether adverse health effects have actually occurred near individual incinerators, and most of them have been unable to detect any effects. The studies of which the committee is aware that did report finding health effects had shortcomings and failed to provide convincing evidence /67/.

That result is not surprising given the small populations typically available for study and the fact that such effects, if any, might occur only infrequently or take many years to appear. Also, factors such as emissions from other pollution sources and variations in human activity patterns often decrease the likelihood of determining a relationship between small contributions of pollutants from incinerators and observed health effects. Lack of evidence of such relationships might mean that adverse health effects did not occur, but it could also mean that such relationships might not be detectable using available methods and data sources.

Pollutants emitted by incinerators that appear to have the potential to cause the largest health effects are particulate matter, lead, mercury, and dioxins and furans. However, there is wide variation in the contributions that incinerators can make to environmental concentrations of those contaminants. Although emissions from newer, well-run facilities are expected to contribute little to environmental concentrations and to health risks, the same might not be true for some older or poorly run facilities.

10.4.1 Regulation of Waste Incineration Facilities in the USA

Waste-incineration facilities are required to comply with a combination of federal, state, and local regulations that vary from place to place and time to time. The US EPA has proposed or has promulgated separate regulations for incineration of medical, hazardous, and municipal solid wastes to reduce emissions to values achieved by the best-controlled 12% of incinerators. This standard is known as “maximum achievable control technology,” or MACT. Facilities that meet the MACT requirements are generally expected to have substantially lower emissions.

The intended reduction in emissions would lower exposures and possible risks to populations surrounding incinerators, especially for particulate matter, lead, mercury, and other metals. However, the effects of such regulations are less apparent when emissions of the most-important pollutants from all incineration sources are considered on a regional scale. For example, the collective contribution of dioxins from multiple incineration sources might remain problematic despite MACT regulations. Because the collective effects of incinerators on metropolitan or regional scales are largely unknown, it is uncertain whether implementation of MACT standards for incinerators will substantially reduce the actual risks posed by persistent environmental pollutants at those scales.

Based on estimates of incinerator emissions, environmental transport and fate, potential total exposure, and relative toxicity of the individual substances inferred from studies not involving incineration, the committee concludes.

Compliance with MACT regulations is expected to reduce substantially local population exposures, especially for particulate matter, lead, mercury and other metals, acidic gases, and acidic aerosols.

Substantial concerns about regional dioxin and furan exposures and moderate concerns about regional exposures to metals are not expected to be relieved by MACT regulations, because the regulations may not adequately reduce risks attributable to cumulative emissions on a regional basis.

Substantial concerns about workers' exposures to particulate matter, lead, mercury, and dioxins and furans are not expected to be relieved by MACT compliance, because those regulations were not designed to affect workers' exposures.

10.4.2 Recommendations by the US Committee

Technologies used in other countries for combustion, emission control, continuous emission monitoring, and public dissemination of information, as well as optimum operating practices, should be actively studied and considered for adoption in the United States.

All regulated medical-waste incinerators and municipal solid-waste combustors should have uniform limits for each pollutant, irrespective of plant size, design, age, or feedstock, as is the case for hazardous-waste combustors. The same technology for air-pollution control is applicable to small and large facilities. Allowing less-stringent limitations for some designs or sizes is inconsistent with the principle of minimizing risks of health effects.

Government agencies should encourage research, development, and demonstration of continuous emission monitors (CEMs), dissemination technologies, and computer programs that automatically analyze, summarize, and report CEM data. In addition to the CEMs already required in municipal solid waste incinerator rules, requirement of CEMs for hydrochloric acid and particulate-matter should be considered on such incinerators.

Also, as soon as a mercury monitor that measures ionic and metallic forms of mercury emissions has been proven reliable, EPA should consider its use for domestic incinerators. The same approach should be used for other monitors, including those for other heavy metals and dioxins and furans. EPA should also explore the utility of technologies such as direct electronic transmission and display to disseminate CEM data to regulatory authorities and the public. Providing such data and data summaries on the Internet should be considered.

In future regulatory decision-making, greater consideration should be given to emission levels achieved in actual performance of incinerators, including process upset conditions (described earlier). In monitoring for compliance or other purposes, data generated during the intervals in which a facility is in start-up, shutdown, and upset conditions should be included in the hourly emission data recorded and published. It is during those times that the highest emissions may occur, and omitting them systematically from monitoring data records does not allow for a full characterization of the actual emissions from an incineration facility /67/.

11 International Legislation on Hazardous Waste and Incineration

11.1 International Agreements

11.1.1 The Basel convention

The Convention /46/ aims, in introducing a system for controlling the export, import and disposal of hazardous wastes and their disposal, to reduce the volume of such exchanges so as to protect human health and the environment.

It defines hazardous wastes. The following wastes that are subject to transboundary movement shall be "hazardous wastes"

(a) Wastes that belong to any category contained in Annex I, unless they do not possess any of the characteristics contained in Annex III; and

(b) Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the Party of export, import or transit.

The approach with the list and the Annex concerning properties appear to be similar to the approach in the hazardous waste directive. The list of properties in the directive is broader, since the properties "mutagenic, irritant and teratogenic" are included.

The convention contains mostly provisions concerning transboundary movement of hazardous waste. However, there are few provisions concerning environmentally sound management of hazardous waste which applies within a state.

Parties to the Convention must cooperate with each other in order to improve and achieve environmentally sound management of hazardous wastes and other wastes. The aim is to implement all practical measures to ensure that wastes covered by the Convention are handled in such a way that protection of human health and the environment from their harmful effects is guaranteed.

Article 4 (2) includes provisions on environmentally sound management of hazardous waste. These apply within the State irrespective of being part of a transboundary movement. Art 4 (2) contains the following obligations

Each party shall take appropriate measures to

- Ensure that generation of hazardous wastes and other wastes, within it, is reduced to a minimum, taking into account social, technological, and economic aspects.

- Ensure the availability of adequate disposal facilities for the environmental sound management of hazardous wastes and other wastes that shall be located, to the extent possible, within it, whatever the place of the disposal.

- Ensure that persons involved in the management of hazardous wastes or other wastes within it takes such steps as are necessary to prevent pollution due to hazardous waste and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment.

11.1.2 The Stockholm Convention

11.2 EU Legislation

11.2.1 EU Waste Legislation

The EU directives on waste are organised into four groups with the Directive on waste (2006/12/EC) representing the overall "framework" of EU regulations. This directive lays down requirements for all types of waste, unless they are specifically regulated by other directives. The other part of the waste framework legislation is the Hazardous Waste Directive, providing for the management, recovery and correct disposal of hazardous waste.

In addition to the Waste Framework Directive, a number of other directives regulate specific waste streams. These are titanium dioxide waste, packaging and packaging waste, waste oils, PCBs and PCTs, batteries and accumulators, sewage sludge, end-of life vehicles (ELV), waste electrical and electronic equipment (WEEE), mining waste as well as port reception facilities for waste from ships and cargo residues.

Finally, a group of directives regulate waste treatment operations: incineration of municipal and hazardous waste, and disposal of waste through landfilling. A specific type of permit is required for certain waste management operations under Council Directive 96/61/EC on integrated pollution prevention and control.

Council Regulation 1013/2006 regulates trans-frontier shipments of waste /51/.

A schematic overview of the EU waste legislation is provided below.

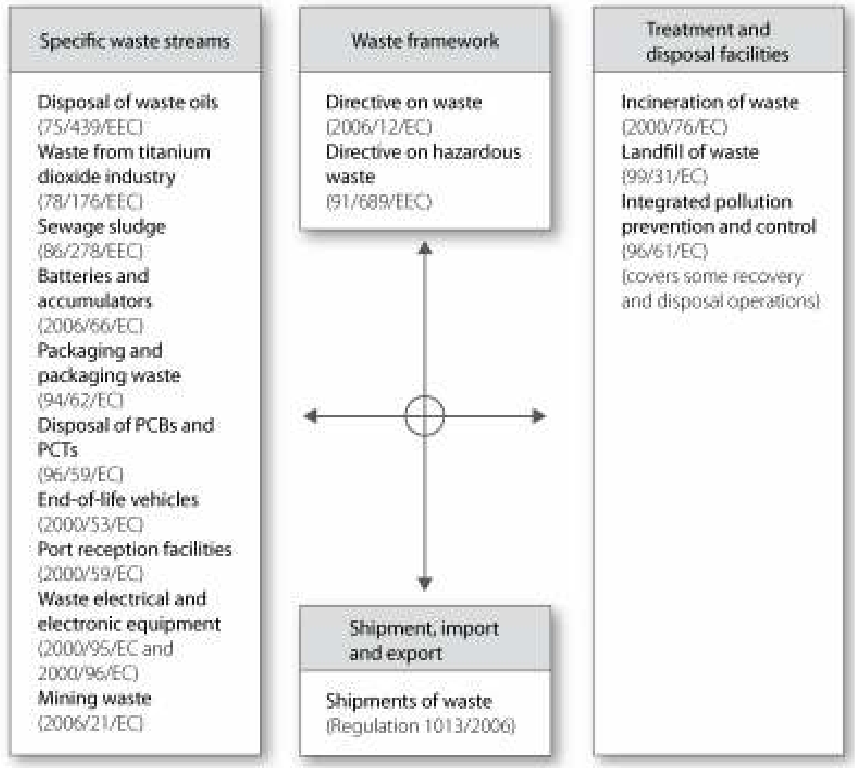

Figure 11: A schematic overview of the EU waste legislation

11.2.2 EU Waste management principles

EU policy on waste management /40/ is set out in the Community Strategy for Waste Management /41 / and is embodied in the Waste Framework Directive (2006/12/EC) and the supporting Hazardous Waste Directive (91/689/EEC) as well as in a Regulation on waste shipments (1013/2006/EC). Numerous wastes stream specific directives complement this framework. It can be said that the EU recognises seven overarching principles for waste management, which are described below.

- **Waste Management Hierarchy.** Waste management strategies must aim primarily to prevent the generation of waste and to reduce its harmfulness. Where this is not possible, waste materials should be reused, recycled or recovered, or used as a source of energy. As a final resort, waste should be disposed of safely (e.g. by incineration or in landfill sites).

- **Self-Sufficiency** at Community and, if possible, at Member State level. Member States need to establish, in co-operation with other Member States an integrated and adequate network of waste disposal facilities.

- Best Available Technique Not Entailing Excessive Cost **(BATNEEC).** Emissions from installations to the environment should be reduced as much as possible and in the most economically efficient way.

- **Proximity.** Wastes should be disposed of as close to the source as possible.

- **Precautionary principle.** The lack of full scientific certainty should not be used as an excuse for failing to act. Where there is a credible risk to the environment or human health of acting or not acting with regard to waste which serves to provide, a cost-effective response to the risk identified should be pursued.

- **Producer Responsibility.** Economic operators, and particularly manufacturers of products, have to be involved in the objective to close the life cycle of substances, components and products from their production throughout their useful life until they become a waste.

- **Polluter pays.** Those responsible for generating or for the generation of waste, and consequent adverse effects on the environment, should be required to pay the costs of avoiding or alleviating those adverse consequences.

In addition to these main principles, the EU's waste management policies also seek to achieve a number of other objectives, which are summarised below.

A common definition of waste across Member States
Waste is defined by the Waste Framework Directive as "any substance or object in the categories set out in Annex I (the list of waste) which the holder discards or intends or is required to discard". Annex I contains a "catch-all" definition of any substance not included in the previous specific categories. The intention behind such an approach is to provide a definition of waste that is as inclusive as possible, not exclusive. Council Directive 91/689/EEC on hazardous waste contains a definition of hazardous wastes based on intrinsic hazard.

Encouragement of clean products: By encouraging the development, manufacturing and consumption of clean products, it should be possible to reduce the environmental impact of a product through its full lifecycle. This "cradle to grave" approach can be seen further embodied and enhanced by European Parliament and Council Directive 2000/53/EC on end-of-life vehicles (see further below).

Encourage the use of economic instruments. This approach aims to influence environmental performance through market mechanisms. Various types of economic instruments are available such as taxes or fees on waste production, transport and disposal; tradable permits on waste production; tradable certificates on recycling; deposits on beverage containers; and import duties on waste that is difficult to dispose of.

Regulate the shipment of waste. Waste legislation seeks to regulate the shipment of waste between Member States, as well as to and from Member States to countries beyond the EU. For domestic waste shipments within one Member State, Member States are obliged to establish supervision and control system that is coherent with the Community system.

The principles of the EU's waste management strategy are implemented primarily, but not exclusively, by EC directives, regulations and decisions that create binding legal obligations.

11.2.3 Waste framework directive

The Waste Framework Directive /42/ lays down general rules that apply to all categories of waste.

The Directive defines wastes as *"any substance or object ... which the holder discards or intends or is required to discard"*. Subsequently, a list of wastes has been established /43/. The Directive establishes the waste management hierarchy, with the objective of waste prevention as the primary objective, followed by reuse and recovery (material recovery or recycling, and energy recovery) over safe waste disposal. A list of disposal and recovery operations is annexed to the Directive, which is currently under review. The Directive requires Member States to draw up waste management plans. It provides for a system of authorization of waste management facilities, including record-keeping obligations and subsequent monitoring, and requires Member States to prohibit the uncontrolled disposal of wastes.

The Member States shall take appropriate measures to encourage

- the prevention or reduction of waste industrial its harmfulness, for instance by the development of clean technologies;
- the recovery of waste by means of recycling, reuse or reclamation or any process with a view to extract secondary raw materials, or the use of waste as a source of energy.

Of equal general nature are the obligations to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment or causing a nuisance through odours or noise or adversely affecting the countryside or places of special interest. The abandonment, dumping or uncontrolled disposal of waste must be prohibited.

Member States are required to establish an integrated and adequate network of disposal installations in order to enable the EU to become self-sufficient in waste disposal and the Member States to move towards that aim individually. The network must also enable waste to be disposed of in one of the nearest appropriate installations.

The Member States shall draw up waste management plans. Movements of waste that is not in accordance with these waste management plans must be prevented.

Undertakings which carry out waste disposal operations or operations which lead to recovery of waste must obtain a permit from the competent authority

In accordance with the polluter pays principle the costs of disposing the waste of waste must be borne by

- The holder of the waste handled by a waste collector and/or
- The previous holder or producer of the product from which the waste came.

All operators in the chain shall be subject to supervision.

11.2.4 The hazardous waste directive

Directive 91/689/EEC /44/ specifically addresses hazardous waste.

Instead of providing for a general definition of hazardous wastes, the Hazardous Waste Directive requires a list of hazardous wastes to be drawn up on the basis of categories, constituents and properties which render them hazardous within the meaning of the Directive.

The directive thus applies to all wastes featuring on the list of hazardous waste. These are wastes which has a number of properties listed in Annex III to the directive (explosive, oxidizing, highly flammable, flammable, irritant, harmful, toxic, carcinogenic, corrosive, infectious, teratogenic, mutagenic). Also included are substances and preparations which release toxic or very toxic gases in contact with water, air or acid as well as substances and preparations capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above. Finally eco-toxic substances are included.

Apart from wastes placed on the list Member States may designate other wastes which they consider to display such properties as hazardous waste.

Worn-out tyres are not considered as hazardous waste.

The Directive establishes additional requirements and obligations for the management of hazardous wastes over and above those laid down in the Framework Directive on wastes, which otherwise applies.

One such additional requirement concerns the prohibition to mix different categories of hazardous wastes or to mix hazardous waste with non-hazardous waste, subject to certain derogations. The Directive makes the disposal of wastes on site subject to a permit requirement. It provides for Member States to draw up hazardous waste management plans

In addition the directive /44/ sets out the following obligations

- Ensure that establishments or undertakings that carry out recovery or disposal of hazardous waste, are also required to obtain a permit from the Competent Authority

- If it is decided to exempt certain establishments or undertakings that recover waste from the requirement to obtain a permit under the Framework Waste Directive, adopt general rules for such establishments and undertakings and ensure that the recovery complies with that Directive

- Require exempt establishments and undertakings to register with the Competent Authorities

- Require producers of hazardous waste, and establishments and undertakings transporting hazardous waste, to keep certain information and to make it available to the Competent Authorities.

- Where hazardous waste is transferred, ensure that it is accompanied by an identification form

- Require that at every site where tipping of hazardous waste takes place, the waste is recorded and identified

- Where hazardous waste is already mixed with other waste, substances or materials, ensure that the waste is separated, where this is technically and economically feasible and necessary to comply with the Framework Waste Directive

- Ensure that in the course of collection, transportation and temporary storage, waste is properly packaged and labelled in accordance with international and EC standards

- In cases of emergency or grave danger, ensure that hazardous waste is dealt with so that it does not constitute a threat to the population or the environment

- Ensure that producers of hazardous waste are subject to appropriate periodic inspections by the Competent Authorities.

- Ensure that for hazardous waste, inspections concerning waste collection and transport operations, made according to the Framework Waste Directive, also cover the origin and destination of the waste.

11.2.5 End-of life-vehicles directive

The End-of-Life-Vehicles (ELV) Directive /40;45/ aim to reduce random disposal of end-of vehicles and used parts thereof and thus the amount of waste from end-of-life vehicles (ELV's). In terms of prevention, the directive restricts in the short term the use of certain heavy metals. In the longer perspective the aim is to change the way that cars are designed and produced in the first place.

The directive sets recovery/recycling targets and requires Member States to ensure that end-of-life-vehicles can only be treated by specifically authorised undertakings/treatment centres and that certificates issued by such undertakings are mutually recognised throughout EU. This is combined with an obligation for the relevant economic operators to establish collection and treatment systems at no expense for the last owner.

The Member States have the following obligations:

- encourage vehicle manufacturers to make vehicles more suitable for recycling, to increase the use of recycled material and to make dismantling of vehicles easy

- ensure the existence of adequate amount of facilities for collection and treatment of ELV's .

- Introduce a permit system for undertakings treating ELV's and encourage the introduction of certified environmental management systems in such undertakings

- make sure that the degree of reuse/recycling/recovery of ELV's reach certain thresholds during coming years with a minimum of 85% of reuse/recovery and a minimum of 80% reuse/recycling of average weight by 1 January 2006 and a minimum of 95% of reuse/recovery and a minimum of 85% reuse/recycling of average weight per vehicle and year to be attained by 2015.

- prohibit the marketing of vehicles, in which there are certain heavy metal components

- require that car producers/distributors set up systems for collection and treatment of ELV's

- ensure that last owner of an ELV can only have it deregistered upon presentation of a certificate of destruction and that such certificates can only be issued if the ELV has been transferred to an authorised collection/treatment facility

- ensure that delivery of ELV's to such facilities does not entail any cost for last owner, and

- ensure that the general requirements of the Waste Framework Directive are observed as regards storage and treatment of ELV's

- make certain that undertakings carrying out treatment of ELV's obtain permits in accordance with waste framework directive

- ensure that such undertakings use certain procedures in order to reduce environmental impact and improve possibilities for reuse, recycling and recovery

- ensure that car producers and distributors etc. provide information on various aspects of the recovery and recyclability qualities of their cars and that such information is included in marketing material etc.

11.2.6 Directive on landfill of waste

The main substantive aim of this Directive /47;48/ is to provide for measures, procedures and guidance to prevent or reduce the negative effects on the environment, and the risks to human health, from landfilling of waste. It requires Member States to take a number of measures to achieve this aim, including treating waste before landfilling it, phasing out co-disposal (the mixing of hazardous waste with non-hazardous waste) and exercising controls over site closure and after-care. Importantly, the polluter pays principle is given effect in two significant ways: (i) by requiring the operator of the landfill to provide financial security for the lifetime of operations at and in relation to the landfill, and (ii) by ensuring that the operator's charges cover "full cost" in relation to the setting up, running, closure and aftercare for the landfill site.

The main policy aims of this Directive are to seek to encourage Member States and operators (including the public) to push waste management higher up the waste hierarchy, so to reduce the desire or need for final disposal, especially by landfill; and to have greater "true" costs applied in relation to landfilling of waste, and with greater transparency (so perhaps aiding achievement of the first policy aim mentioned).

The directive expressly forbids that whole worn-out tyres are landfilled. Also excluded are waste which in the conditions of landfill, is explosive, corrosive, oxidising, highly flammable or flammable, as defined in hazardous waste directive and hospital and other clinical wastes arising from medical or veterinary establishments, which are infectious as defined in the directive on hazardous waste.

The Directive is intended to prevent or reduce the adverse effects of waste landfilling on the environment by introducing stringent technical requirement for waste landfilling. It defines the notion of landfill as including internal waste disposal sites at the location of production, and any sites permanently used for the temporary storage of waste[4].

The Directive applies to all landfills, dividing them into three classes:

- landfills for <u>hazardous</u> wastes
- landfills for <u>non-hazardous</u> wastes
- landfills for <u>inert</u> wastes.

[4] The Directive does not apply to temporary storage of waste prior to recovery or treatment for a period less than three years, and temporary storage of waste prior to disposal for a period less than one year.

The Directive lays down a standard acceptance procedure requiring the treatment of wastes prior to being landfilled and restricts the assignment of inert, non-hazardous and hazardous wastes only to the respective class of landfills listed above.

It also bans the depositing of certain wastes in a landfill, for example liquid wastes, or flammable wastes[5]. In addition, it sets certain targets for the disposal of biodegradable waste in landfills (reduction to 35% of the total generation of municipal biodegradable waste in 1995 by July 2016 or 2020 for countries that landfilled more than 80% of their MSW in 1995).

It furthermore sets up a system of operating permits for landfill sites, requiring a minimum set of information to be contained in the application, such as description of the types and total quantity of waste to be deposited, proposed methods for pollution prevention and abatement, a proposed operation, monitoring and control plan, a plan for closure and aftercare procedures, etc.

The Directive also contains a minimum set of siting and design provision as well as minimum control and monitoring procedures during operation and during the after-care phase following closure of a landfill.

The Directive provides for transitional periods until which all landfills have to comply with the Directive.

11.2.7 EU Incineration of Waste Regulation

The directive on incineration of waste (Directive 2000/76/EC) deals with incineration of municipal and hazardous waste /49/

Incineration of both hazardous and harmless wastes may cause emissions of substances which pollute the air, water and soil and have harmful effects on human health.

This Directive applies not only to facilities intended for waste incineration ("dedicated incineration plants") but also to "co-incineration" plants (facilities whose main purpose is to produce energy or material products and which use waste as a regular or additional fuel, this waste being thermally treated for the purpose of disposal). The Directive does not cover experimental plants for improving the incineration process and which treat less than 50 tonnes of waste per year. Nor does it cover plants treating only:

- vegetable waste from agriculture and forestry, the food processing industry or the production of paper;
- wood waste;

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[5] In 2002, the Commission has presented a proposal for a Council Decision establishing criteria and procedures for the acceptance of waste at landfills, COM (2002)512. The adopted version is Council decision 2003/33/EC

- cork waste;
- radioactive waste;
- animal carcases;
- waste resulting from the exploitation of oil and gas and incinerated on board offshore installations.

All incineration or co-incineration plants must be authorised. Permits will be issued by the competent authority and will list the categories and quantities of hazardous and non-hazardous waste which may be treated, the plant's incineration or co-incineration capacity and the sampling and measurement procedures which are to be used.

Before accepting hazardous waste, operators of incineration or co-incineration plants must have available the prescribed administrative information on the generating processes, information on the physical and chemical composition of hazardous waste, and information on the hazardous characteristics of the waste.

In order to guarantee complete waste combustion, the Directive requires all plants to keep the incineration or co-incineration gases at a temperature of at least 850°C for at least two seconds. If hazardous waste with a content of more than 1% of halogenated organic substances, expressed as chlorine, is incinerated, the temperature has to be raised to 1 100 °C for at least two seconds.

The heat generated by the incineration process has to be put to good use as far as possible.

The limit values for incineration plant emissions to air are set out in Annex V to the Directive. They concern heavy metals, dioxins and furans, carbon monoxide (CO), dust, total organic carbon (TOC), hydrogen chloride (HCl), hydrogen fluoride (HF), sulphur dioxide (SO2), nitrogen monoxide (NO) and nitrogen dioxide (NO2).

The limit values for co-incineration plant emissions to air are set out in Annex II. In addition, special provisions are laid down relating to cement kilns, other industrial sectors, and combustion plants which co-incinerate waste.

All discharges of effluents caused by exhaust-gas clean-up must be authorised. This will ensure that the emission limit values set out in Annex IV to the Directive are not exceeded. Rain or fire fighting water will be collected and analysed before being discharged.

Incineration residues must be reduced to a minimum and, as far as possible, recycled. When dry residues are transported, precautions must be taken to prevent their dispersal in the environment. Tests must be carried out to establish the physical and chemical characteristics, and polluting potential, of residues.

The Directive requires the installation of measurement systems to monitor the parameters and relevant emission limits. Emissions to air and to water must be measured periodically in accordance with Annex III and Article 11 of the Directive.

Applications for new permits must be made accessible to the public so that the latter may comment before the competent authority reaches a decision.

For plants with a nominal capacity of two tonnes or more per hour, the operator must provide the competent authority with an annual report on the functioning and monitoring of the plant, to be made available to the public. A list of plants with a nominal capacity of less than two tonnes per hour must be drawn up by the competent authority and made available to the public.

The directive does not distinguish between incineration plants for municipal and hazardous waste as a main rule. There are exemptions: The requirements for permits in art. 4, para 4 for incineration of hazardous waste includes also a list of quantities of the different categories of hazardous waste which may be treated and a specification of minimum and maximum mass flow of those hazardous wastes, their lowest and maximum calorific values and their maximum contents of pollutants. It does not limit those requirements to dedicated incineration plants for hazardous waste.

There are also specific requirements for provision of information and reception procedures prior to acceptance of hazardous waste, see art. 5, para 3 and 4. There is an additional operating condition as to temperature if hazardous waste with a content of more than 1% of halogenated organic substances is incinerated. Specific emission limit values for air apply if more than 40 % of the resulting heat release from a co-incineration plant comes from hazardous waste, see art. 7, para 2, subpara. 2 and annex V.

Incineration in cement kilns is defined as co-incineration and the relevant provisions for those apply. Annex II on determination of air emission limit values for the co-incineration of waste contains a specific section for cement kilns. Three sets of emission limit values (Total emission limit values, total emission limit values for SO_2 and TOC and emission limit value for CO) are included.

11.2.8 Selective extract from EU Directive on the incineration of waste

Introduction
This selective extract from "Directive 2000/76/EC of 4 December 2000 on the incineration of waste" /73/ with special emphasis on "dedicated" incineration plants and with focus on air pollution control, does not provide all the information in the directive and Annexes mentioned. If this information is needed, please look up the original directive.

Definitions from directive
'Incineration plant' means any stationary or mobile technical unit and equipment dedicated to the thermal treatment of wastes with or without recovery of the combustion heat generated. This includes the incineration by oxidation of waste as well as other thermal treatment processes such as pyrolysis, gasification or plasma processes in so far as the substances resulting from the treatment are subsequently incinerated.

This definition covers the site and the entire incineration plant including all incineration lines, waste reception, storage, on site pre-treatment facilities, waste-fuel and air supply systems, boiler, facilities for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, stack, devices and systems for controlling incineration operations, recording and monitoring incineration conditions;

'Co-incineration plant' means any stationary or mobile plant whose main purpose is the generation of energy or production of material products and:

— which uses wastes as a regular or additional fuel; or

— in which waste is thermally treated for the purpose of disposal

If co-incineration takes place in such a way that the main purpose of the plant is not the generation of energy or production of material products but rather the thermal treatment of waste, the plant shall be regarded as an incineration plant within the meaning of point 4.

This definition covers the site and the entire plant including all co-incineration lines, waste reception, storage, on site pre-treatment facilities, waste-, fuel- and air-supply systems, boiler, facilities for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, stack devices and systems for controlling incineration operations, recording and monitoring incineration conditions;

Application and permit

1. Without prejudice to Article 11 of Directive 75/442/EEC or to Article 3 of Directive 91/689/EEC, no incineration or co-incineration plant shall operate without a permit to carry out these activities.

2. Without prejudice to Directive 96/61/EC, the application for a permit for an incineration or co-incineration plant to the competent authority shall include a description of the measures which are envisaged to guarantee that:

(a) the plant is designed, equipped and will be operated in such a manner that the requirements of this Directive are taking into account the categories of waste to be incinerated;

(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating;

(c) the residues will be minimised in their amount and harmfulness and recycled where appropriate;

(d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Community legislation.

3. The permit shall be granted only if the application shows that the proposed measurement techniques for emissions into the air comply with Annex III and, as regards water, comply with Annex III paragraphs 1 and 2.

4. The permit granted by the competent authority for an incineration or co-incineration plant shall, in addition to complying with any applicable requirement laid down in Directives 91/271/EEC, 96/61/EC, 96/62/EC, 76/464/EEC and 1999/31/EC:

(a) list explicitly the categories of waste which may be treated. The list shall use at least the categories of waste set up in the European Waste Catalogue (EWC), if possible, and contain information on the quantity of waste, where appropriate;

(b) include the total waste incinerating or co-incinerating capacity of the plant;

(c) specify the sampling and measurement procedures used to satisfy the obligations imposed for periodic measurements of each air and water pollutants.

5. The permit granted by the competent authority to an incineration or co-incineration plant using hazardous waste shall in addition to paragraph 4:

(a) list the quantities of the different categories of hazardous waste which may be treated;

(b) specify the minimum and maximum mass flows of those hazardous wastes, their lowest and maximum calorific values and their maximum contents of pollutants, e.g. PCB, PCP, chlorine, fluorine, sulphur, heavy metals.

6. Without prejudice to the provisions of the Treaty, Member States may list the categories of waste to be mentioned in the permit which can be co-incinerated in defined categories of co-incineration plants.

7. Without prejudice to Directive 96/61/EC, the competent authority shall periodically reconsider and, where necessary, update permit conditions.

8. Where the operator of an incineration or co-incineration plant for non-hazardous waste is envisaging a change of operation which would involve the incineration or co-incineration of hazardous waste, this shall be regarded as a

substantial change within the meaning of Article 2(10)(b) of Directive 96/61/EC and Article 12(2) of that Directive shall apply.

9. If an incineration or co-incineration plant does not comply with the conditions of the permit, in particular with the emission limit values for air and water, the competent authority shall take action to enforce compliance.

Operating Conditions

1. Incineration plants shall be operated in order to achieve a level of incineration such that the slag and bottom ashes Total Organic Carbon (TOC) content is less than 3 % or their loss on ignition is less than 5 % of the dry weight of the material. If necessary, appropriate techniques of waste pre-treatment shall be used.

Incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the process is raised, after the last injection of combustion air, in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850 °C, as measured near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, for two seconds. If hazardous wastes with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are incinerated, the temperature has to be raised to 1 100 °C for at least two seconds. Each line of the incineration plant shall be equipped with at least one auxiliary burner. This burner must be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below 850 °C or 1 100 °C as the case may be. It shall also be used during plant start-up and shut-down operations in order to ensure that the temperature of 850 °C or 1100°C as the case may be is maintained at all times during these operations and as long as unburned waste is in the combustion chamber.

During start-up and shut-down or when the temperature of the combustion gas falls below 850 °C or 1100°C as the case may be, the auxiliary burner shall not be fed with fuels which can cause higher emissions than those resulting from the burning of gasoil as defined in Article 1(1) of Council Directive 75/716/EEC, liquefied gas or natural gas.

2. Co-incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the co-incineration of waste is raised in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850 °C for two seconds. If hazardous wastes with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are co-incinerated, the temperature has to be raised to 1 100 °C.

3. Incineration and co-incineration plants shall have and operate an automatic system to prevent waste feed:

(a) at start-up, until the temperature of 850 °C or 1 100 °C as the case may be or the temperature specified according to paragraph 4 has been reached;

(b) whenever the temperature of 850 °C or 1100°C as the case may be or the temperature specified according to paragraph 4 is not maintained;

(c) whenever the continuous measurements required by this Directive show that any emission limit value is exceeded due to disturbances or failures of the purification devices.

4. Conditions different from those laid down in paragraph 1 and, as regards the temperature, paragraph 3 and specified in the permit for certain categories of waste or for certain thermal processes may be authorised by the competent authority provided the requirements of this Directive are met. Member States may lay down rules governing these authorisations. The change of the operational conditions shall not cause more residues or residues with a higher content of organic pollutants compared to those residues which could be expected under the conditions laid down in paragraph 1.

Conditions different from those laid down in paragraph 2 and, as regards the temperature, paragraph 3 and specified in the permit for certain categories of waste or for certain thermal processes may be authorised by the competent authority, provided the requirements of this Directive are met. Member States may lay down rules governing these authorisations. Such authorisation shall be conditional upon at least the provisions for emission limit values set out in Annex V for total organic carbon and CO being complied with. In the case of co-incineration of their own waste at the place of its production in existing bark boilers within the pulp and paper industry, such authorisation shall be conditional upon at least the provisions for emission limit values set out in Annex V for total organic carbon being complied with.

All operating conditions determined under this paragraph and the results of verifications made shall be communicated by the Member State to the Commission as part of the information provided in accordance with the reporting requirements.

5. Incineration and co-incineration plants shall be designed, equipped, built and operated in such a way as to prevent emissions into the air giving rise to significant ground-level air pollution; in particular, exhaust gases shall be discharged in a controlled fashion and in conformity with relevant Community air quality standards by means of a stack the height of which is calculated in such a way as to safeguard human health and the environment.

6. Any heat generated by the incineration or the co-incineration process shall be recovered as far as practicable.

7. Infectious clinical waste should be placed straight in the furnace, without first being mixed with other categories of waste and without direct handling.

8. The management of the incineration or the co-incineration plant shall be in the hands of a natural person who is competent to manage the plant.

Air emission limit values

1. Incineration plants shall be designed, equipped, built and operated in such a way that the emission limit values set out in Annex V are not exceeded in the exhaust gas.

2. Co-incineration plants shall be designed, equipped, built and operated in such a way that the emission limit values determined according to or set out in Annex II are not exceeded in the exhaust gas. If in a co-incineration plant more than 40 % of the resulting heat release comes from hazardous waste, the emission limit values set out in Annex V shall apply.

3. The results of the measurements made to verify compliance with the emission limit values shall be standardised with respect to the conditions laid down in Article 11.

4. In the case of co-incineration of untreated mixed municipal waste, the limit values will be determined according to Annex V, and Annex II will not apply.

5. Without prejudice to the provisions of the Treaty, Member States may set emission limit values for polycyclic-aromatic hydrocarbons or other pollutants.

Control and monitoring

1. Measurement equipment shall be installed and techniques used in order to monitor the parameters, conditions and mass concentrations relevant to the incineration or co-incineration process.

2. The measurement requirements shall be laid down in the permit or in the conditions attached to the permit issued by the competent authority.

3. The appropriate installation and the functioning of the automated monitoring equipment for emissions into air and water shall be subject to control and to an annual surveillance test. Calibration has to be done by means of parallel measurements with the reference methods at least every three years.

4. The location of the sampling or measurement points shall be laid down by the competent authority.

5. Periodic measurements of the emissions into the air and water shall be carried out in accordance with Annex III, points 1 and 2.

Measurement requirements

1. Member States shall, either by specification in the conditions of the permit or by general binding rules, ensure that paragraphs 2 to 12 and 17, as regards air, and paragraphs 9 and 14 to 17, as regards water, are complied with.

2. The following measurements of air pollutants shall be carried out in accordance with Annex III at the incineration and co-incineration plant:

(a) continuous measurements of the following substances: NOx, provided that emission limit values are set, CO, total dust, TOC, HCl, HF, SO2;

(b) continuous measurements of the following process operation parameters: temperature near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, concentration of oxygen, pressure, temperature and water vapour content of the exhaust gas;

(c) at least two measurements per year of heavy metals, dioxins and furans; one measurement at least every three months shall however be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

3. The residence time as well as the minimum temperature and the oxygen content of the exhaust gases shall be subject to appropriate verification, at least once when the incineration or co-incineration plant is brought into service and under the most unfavourable operating conditions anticipated.

4. The continuous measurement of HF may be omitted if treatment stages for HCl are used which ensure that the emission limit value for HCl is not being exceeded. In this case the emissions of HF shall be subject to periodic measurements as laid down in paragraph 2(c).

5. The continuous measurement of the water vapour content shall not be required if the sampled exhaust gas is dried before the emissions are analysed.

6. Periodic measurements as laid down in paragraph 2(c) of HCl, HF and SO2 instead of continuous measuring may be authorised in the permit by the competent authority in incineration or co-incineration plants, if the operator can prove that the emissions of those pollutants can under no circumstances be higher than the prescribed emission limit values.

7. The reduction of the frequency of the periodic measurements for heavy metals from twice a year to once every two years and for dioxins and furans from twice a year to once every year may be authorised in the permit by the competent authority provided that the emissions resulting from co-incineration or incineration are below 50 % of the emission limit values determined according to Annex II or Annex V respectively and provided that criteria for the requirements to be met, developed in accordance with the procedure laid down in Article 17, are available. These criteria shall at least be based on the provisions of the second subparagraph, points (a) and (d). Until 1 January 2005 the reduction of the frequency may be authorised even if no such criteria are available provided that:

(a) the waste to be co-incinerated or incinerated consists only of certain sorted combustible fractions of non-hazardous waste not suitable for recycling and presenting certain characteristics, and which is further specified on the basis of the assessment referred to in subparagraph (d);

(b) national quality criteria, which have been reported to the Commission, are available for these wastes;

(c) co-incineration and incineration of these wastes is in line with the relevant waste management plans referred to in Article 7 of Directive 75/442/EEC;

(d) the operator can prove to the competent authority that the emissions are under all circumstances significantly below the emission limit values set out in Annex II or Annex V for heavy metals, dioxins and furans; this assessment shall be based on information on the quality of the waste concerned and measurements of the emissions of the said pollutants;

(e) the quality criteria and the new period for the periodic measurements are specified in the permit; and

(f) all decisions on the frequency of measurements referred to in this paragraph, supplemented with information on the amount and quality of the waste concerned, shall be communicated on a yearly basis to the Commission.

8. The results of the measurements made to verify compliance with the emission limit values shall be standardised at the following conditions and for oxygen according to the formula as referred to in Annex VI:

(a) Temperature 273 K, pressure 101,3 kPa, 11 % oxygen, dry gas, in exhaust gas of incineration plants;

(b) Temperature 273 K, pressure 101,3 kPa, 3 % oxygen, dry gas, in exhaust gas of incineration of waste oil as defined in Directive 75/439/EEC;

(c) when the wastes are incinerated or co-incinerated in an oxygen-enriched atmosphere, the results of the measurements can be standardised at an oxygen content laid down by the competent authority reflecting the special circumstances of the individual case;

(d) in the case of co-incineration, the results of the measurements shall be standardised at a total oxygen content as calculated in Annex II. When the emissions of pollutants are reduced by exhaust gas treatment in an incineration or co-incineration plant treating hazardous waste, the standardisation with respect to the oxygen contents provided for in the first subparagraph shall be done only if the oxygen content measured over the same period as for the pollutant concerned exceeds the relevant standard oxygen content.

9. All measurement results shall be recorded, processed and presented in an appropriate fashion in order to enable the competent authorities to verify compliance with the permitted operating conditions and emission limit values laid down in this Directive in accordance with procedures to be decided upon by those authorities.

10. The emission limit values for air shall be regarded as being complied with if:

(a) — none of the daily average values exceeds any of the emission limit values set out in Annex V(a) or Annex II;

— 97 % of the daily average value over the year does not exceed the emission limit value set out in Annex V(e) first indent;

(b) either none of the half-hourly average values exceeds any of the emission limit values set out in Annex V(b), column A or, where relevant, 97 % of the half-hourly average values over the year do not exceed any of the emission limit values set out in Annex V(b), column B;

(c) none of the average values over the sample period set out for heavy metals and dioxins and furans exceeds the emission limit values set out in Annex V(c) and (d) or Annex II;

(d) the provisions of Annex V(e), second indent or Annex II, are met.

11. The half-hourly average values and the 10-minute averages shall be determined within the effective operating time (excluding the start-up and shut-off periods if no waste is being incinerated) from the measured values after having subtracted the value of the confidence interval specified in point 3 of Annex III. The daily average values shall be determined from those validated average values. To obtain a valid daily average value no more than five half hourly average values in any day shall be discarded due to malfunction or maintenance of the continuous measurement system. No more than ten daily average values per year shall be discarded due to malfunction or maintenance of the continuous measurement system.

12. The average values over the sample period and the average values in the case of periodical measurements of HF, HCl and SO2 shall be determined in accordance with the requirements of Article 10(2) and (4) and Annex III.

13. The Commission, acting in accordance with the procedure laid down in Article 17, shall decide, as soon as appropriate measurement techniques are available within the Community, the date from which continuous measurements of the air emission limit values for heavy metals, dioxins and furans shall be carried out in accordance with Annex III.

14. The following measurements shall be carried out at the point of waste water discharge:

(a) continuous measurements of the parameters referred to in Article 8(6)(b);

(b) spot sample daily measurements of total suspended solids; Member States may alternatively provide for measurements of a flow proportional representative sample over a period of 24 hours;

(c) at least monthly measurements of a flow proportional representative sample of the discharge over a period of 24 hours of the polluting substances referred to in Article 8(3) with respect to items 2 to 10 in Annex IV;

(d) at least every six months measurements of dioxins and furans; however one measurement at least every three months shall be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

15. The monitoring of the mass of pollutants in the treated waste water shall be done in conformity with Community legislation and laid down in the permit as well as the frequency of the measurements.

16. The emission limit values for water shall be regarded as being complied with if:

(a) for total suspended solids (polluting substance number 1), 95 % and 100 % of the measured values do not exceed the respective emission limit values as set out in Annex IV;

(b) for heavy metals (polluting substances number 2 to 10) no more than one measurement per year exceeds the emission limit values set out in Annex IV; or, if the Member State provides for more than 20 samples per year, no more than 5 % of these samples exceed the emission limit values set out in Annex IV;

(c) for dioxins and furans (polluting substance 11), the twice yearly measurements do not exceed the emission limit value set out in Annex IV.

17. Should the measurements taken show that the emission limit values for air or water laid down in this Directive have been exceeded, the competent authorities shall be informed without delay.

Abnormal operating conditions

1. The competent authority shall lay down in the permit the maximum permissible period of any technically unavoidable stoppages, disturbances, or failures of the purification devices or the measurement devices, during which the concentrations in the discharges into the air and the purified waste water of the regulated substances may exceed the prescribed emission limit values.

2. In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored.

3. Without prejudice to Article 6(3)(c), the incineration plant or co-incineration plant or incineration line shall under no circumstances continue to incinerate waste for a period of more than four hours uninterrupted where emission limit values are exceeded; moreover, the cumulative duration of operation in such conditions over one year shall be less than 60 hours. The 60-hour duration applies to those lines of the entire plant which are linked to one single flue gas cleaning device.

4. The total dust content of the emissions into the air of an incineration plant shall under no circumstances exceed 150 mg/m3 expressed as a half-hourly average; moreover the air emission limit values for CO and TOC shall not be exceeded. All other conditions referred to in Article 6 shall be complied with Annex III.

Measurement techniques

1. Measurements for the determination of concentrations of air and water polluting substances have to be carried out representatively.

2. Sampling and analysis of all pollutants including dioxins and furans as well as reference measurement methods to calibrate automated measurement systems shall be carried out as given by CEN-standards. If CEN standards are not available, ISO standards, national or international standards which will ensure the provision of data of an equivalent scientific quality shall apply.

3. At the daily emission limit value level, the values of the 95 % confidence intervals of a single measured result shall not exceed the following percentages of the emission limit values:

Carbon monoxide: 10 %
Sulphur dioxide: 20 %
Nitrogen dioxide: 20 %
Total dust: 30 %
Total organic carbon: 30 %
Hydrogen chloride: 40 %
Hydrogen fluoride: 40 %.

ANNEX V

AIR EMISSION LIMIT VALUES

(a) **Daily average values**

Total dust	10 mg/m3
Gaseous and vaporous organic substances, expressed as total organic carbon	10 mg/m3
Hydrogen chloride (HCl)	10 mg/m3
Hydrogen fluoride (HF)	1 mg/m3
Sulphur dioxide (SO2)	50 mg/m3
Nitrogen monoxide (NO) and nitrogen dioxide (NO2) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	200 mg/m3 (*)
Nitrogen monoxide (NO) and nitrogen dioxide (NO2), expressed as nitrogen dioxide for existing incineration plants with a nominal capacity of 6 tonnes per hour or less	400 mg/m3 (*)

(*) Until 1 January 2007 and without prejudice to relevant (Community) legislation the emission limit value for NOx does not apply to plants only incinerating hazardous waste.

Exemptions for NOx may be authorised by the competent authority for existing incineration plants:

— with a nominal capacity of 6 tonnes per hour, provided that the permit foresees the daily average values do not exceed 500 mg/m3 and this until 1 January 2008,

— with a nominal capacity of >6 tonnes per hour but equal or less than 16 tonnes per hour, provided the permit foresees the daily average values do not exceed 400 mg/m3 and this until 1 January 2010,

— with a nominal capacity of >16 tonnes per hour but <25 tonnes per hour and which do not produce water discharges, provided that the permit foresees the daily average values do not exceed 400 mg/m3 and this until 1 January 2008.

Until 1 January 2008, exemptions for dust may be authorised by the competent authority for existing incinerating plants, provided that the permit foresees the daily average values do not exceed 20 mg/m3.

(b) **Half-hourly average values**

	(100 %) A	**(97 %) B**
Total dust	30 mg/m3	10 mg/m3
Gaseous and vaporous organic substances, expressed as total organic carbon	20 mg/m3	10 mg/m3
Hydrogen chloride (HCl)	60 mg/m3	10 mg/m3
Hydrogen fluoride (HF)	4 mg/m3	2 mg/m3
Sulphur dioxide (SO2)	200 mg/m3	50 mg/m3
Nitrogen monoxide (NO) and nitrogen dioxide (NO2), expressed as nitrogen dixoide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	400 mg/m3(*)	200 mg/m3(*)

(*) Until 1 January 2007 and without prejudice to relevant Community legislation the emission limit value for NOx does not apply to plants only incinerating hazardous waste.

Until 1 January 2010, exemptions for NOx may be authorised by the competent authority for existing incineration plants with a nominal capacity between 6 and

16 tonnes per hour, provided the half-hourly average value does not exceed 600 mg/m3 for column A or 400 mg/m3 for column B.

(c) **All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours**

Cadmium and its compounds, expressed as cadmium (Cd)	total 0.05 mg/m3	total 0.1 mg/m3 (*)
Thallium and its compounds, expressed as thallium (Tl)		
Mercury and its compounds, expressed as mercury (Hg)	0.05 mg/m3	0.1 mg/m3 (*)
Antimony and its compounds, expressed as antimony (Sb)	total 0.5 mg/m3	total 1 mg/m3 (*)
Arsenic and its compounds, expressed as arsenic (As)		
Lead and its compounds, expressed as lead (Pb)		
Chromium and its compounds, expressed as chromium (Cr)		
Cobalt and its compounds, expressed as cobalt (Co)		
Copper and its compounds, expressed as copper (Cu)		
Manganese and its compounds, expressed as manganese(Mn)		
Nickel and its compounds, expressed as nickel (Ni)		
Vanadium and its compounds, expressed as vanadium (V)		
(*) Until 1 January 2007 average values for existing plants for which the permit to operate has been granted before 31 December 1996, and which incinerate hazardous waste only.		

These average values cover also gaseous and the vapour forms of the relevant heavy metal emissions as well as their compounds.

(d) **Average values shall be measured over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalence in accordance with Annex I.**

Dioxins and furans	0.1 ng/m3

(e) **The following emission limit values of carbon monoxide (CO) concentrations shall not be exceeded in the combustion gases (excluding the start-up and shut-down phase):**

— 50 milligrams/m3 of combustion gas determined as daily average value;

— 150 milligrams/m3 of combustion gas of at least 95 % of all measurements determined as 10-minute average

values or 100 mg/m3 of combustion gas of all measurements determined as half-hourly average values taken in any 24-hour period.

Exemptions may be authorised by the competent authority for incineration plants using fluidised bed technology, provided that the permit foresees an emission limit value for carbon monoxide (CO) of not more than 100 mg/m3 as an hourly average value.

(f) **Member States may lay down rules governing the exemptions provided for in this Annex.**

11.2.9 Other EU permitting requirements

Furthermore the IPPC Directive /50/ provides for an integrated permitting procedure[6]. It lays down minimum requirements included in any such permit (compliance with the basic obligations, emission limits for pollutants to the air and water, monitoring discharges etc.). The Directive applies to installations of a certain size in the energy, metals, mineral and chemical industries, as well as to waste management operations, including the landfilling of wastes.

It contains general principles for the operation of the installations covered, including the requirement to apply best available techniques (BAT) in order to prevent pollution, to implement the waste management hierarchy, to use energy efficiently, to take the necessary measures so as to prevent accidents and limit their consequences, and to return the site of operation to "a satisfactory state" upon definite closure of the installation.

The Directive provides for a transitional period by which time all installations covered have to comply with the Directive.

11.3 Australian Legislation

In Australia, the general principle is that the federal government sets policy and the states are responsible for implementation.

11.3.1 National (Federal) Legislation

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) protects the environment, particularly matters of National Environmental Significance. It streamlines national environmental assessment and approvals

[6] "Integrated" means that the permits must take into account the *whole* environmental performance of the plant, i.e. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, risk management, etc.

process, protects Australian biodiversity and integrates management of important natural and cultural places. The EPBC Act came into force on 16 July 2000 /52/.

Approval is required for actions that are likely to have a significant impact on:

- a matter of national environmental significance;
- the environment of Commonwealth land (even if taken outside Commonwealth land); and
- the environment anywhere in the world (if the action is undertaken by the Commonwealth).

An action includes a project, development, undertaking, activity, or series of activities.

11.3.2 Sea Dumping

A person is guilty of an offence against this section if, otherwise than in accordance with a permit, the person /53/:

- dumps controlled material into Australian waters from any vessel, air craft or platform; or
- dumps controlled material into any part of the sea from any Australian vessel or Australian aircraft; or
- dumps a vessel, aircraft or platform into Australian waters; or dumps an Australian vessel or Australian aircraft into any part of the sea.

11.3.3 Hazardous Waste

The Department of the Environment and Water Resources administers and implements the *Hazardous Waste (Regulation of Exports and Imports) Act 1989* ('the Act'). The Act was developed to enable Australia to comply with specific obligations under the Basel Convention (Basel Convention on the Control of the Transboundary Movements of Hazardous Wastes and their disposal), a Convention set up to control the international movements of hazardous wastes/54/.

The main purpose of the Hazardous Waste Act (‘the Act’) is to regulate the export and import of hazardous waste to ensure that hazardous waste is disposed of safely so that human beings and the environment, both within and outside Australia, are protected from the harmful effects of the waste.

The original Act of 1989 only controlled movements of wastes that lacked financial value, usually destined for final disposal operations (for example, by incineration or landfill). In 1996, the Act was amended to include wastes that possess financial value, usually destined for recycling and recovery operations. These amendments enabled Australia to meet all of its obligations under the Basel Convention.

You need to know about the Act if:

- you are a waste broker, agent or dealer;
- you plan to move hazardous waste in and out of Australia;
- you produce hazardous waste which will be exported; or
- you import hazardous waste for recovery or final disposal.

The Act requires that a permit be obtained before hazardous waste is exported from Australia or imported into Australia.

11.3.4 EPA Victoria State Legislation

Waste is something that is left over or that it is no longer needed. Waste can cause pollution and impact on our environment if not properly managed. Disposing of waste that cannot be otherwise avoided, reused or recycled also represents a waste of resources, a lost opportunity and is a waste of money.

EPA works in partnership with all levels of government, industry and the community to facilitate sustainable solutions for waste management.

All industries, businesses and consumers generate waste. A baby wearing disposable nappies; manufacturing of a motor car; a child throwing away the packaging from a muesli bar; demolishing a building and using plastic supermarket shopping bags are all examples of activities that generate waste.

Waste is defined by the *Environment Protection Act 1970* as any matter prescribed to be waste and any matter, whether liquid, solid, gaseous or radioactive, which is discharged, emitted or deposited in the environment in such volume or manner as to cause an alteration of the environment.

Types of waste

EPA is responsible for the development and implementation of Victoria's statutory framework for waste. The framework provides for solid wastes, such as municipal (household) wastes, commercial and industrial wastes, and prescribed wastes.

Municipal wastes are mainly generated by households and include food scraps, packaging and garden material. Municipal wastes are typically collected by local councils through kerbside collections, where some of the waste is recycled (such as paper, glass, plastics and green waste) and some disposed of to landfill.

Commercial and industrial wastes are generated by industry that pose low hazard to the environment. They arise from commercial, industrial or trade activities, and include construction and demolition wastes.

Prescribed wastes include hazardous wastes and wastes that can affect amenity (for example odour). Prescribed wastes are listed in the *Environment Protection (prescribed waste) Regulations 1998*. The majority of these wastes are from industrial sources and are referred to as prescribed industrial wastes.

11.3.5 Prescribed waste

Prescribed wastes include potentially hazardous wastes, but also wastes that may affect amenity (for example via odor impacts). Certain types of wastes are legally referred to as prescribed industrial wastes (prescribed wastes which are generated from commercial or industrial sources). Not all wastes generated from commercial or industrial premises are prescribed, just those listed in the *Environment Protection (Prescribed Waste) Regulations 1998*, because of their potential adverse impacts on human health and the environment, or impact on public amenity (for example odorous waste).

Prescribed industrial wastes make up most of the listed prescribed wastes, with exceptions including grease interceptor trap waste from domestic sources and domestic asbestos waste. Prescribed industrial wastes need to be carefully managed and are closely regulated.

The terms prescribed industrial waste and hazardous waste are sometimes used interchangeably, however under the statutory framework administered by EPA the term 'prescribed industrial waste' has a specific meaning. The term hazardous waste does not have a statutory definition.

Accelerating reductions in hazardous wastes

Since 2000, Victorian industry, with support from EPA, has reduced the amount of high and low hazard waste sent to landfill by 30 per cent. These reductions are good progress, but further significant reductions are needed. Victoria has a strategy to accelerate these reductions into the future and to remove high-hazard wastes from landfill by 2020 through increased regulation, cost incentives and supporting industry to reduce waste.

What are hazardous wastes and where do they come from?

Much goods and services are produced by Victorian industry on a day-to-day basis. Providing these goods and services generates wastes, including high and low-hazard wastes. Some common examples of industries that generate high-hazard wastes include car repair workshops, dry cleaning services, chemical, paint and plastics manufacturing. Low-hazard wastes include food processing, seafood and poultry wastes.

'High-hazard waste' does not have a statutory meaning, but is a descriptive term for waste that requires a higher level of control to protect human health and the environment. Similarly, 'low-hazard waste' is a term used for waste that poses a low hazard or only impacts on amenity, such as odorous waste.

Where we've been

Since 2000, Victorian industry, with support from V-EPA, has reduced the amount of high and low-hazard waste sent to landfill from 122,000 tonnes to 85,000 in 2006 — a reduction of 30 per cent.

Where we're heading

These reductions are good progress, but further significant reductions are needed. Victoria has a strategy to accelerate these reductions into the future and to remove high-hazard wastes from landfill by 2020 through increased regulation, cost incentives, and supporting industry to invest in new technologies, processes and infrastructure to reduce waste.

Tighter controls and banning some wastes from landfill

More stringent waste acceptance standards at landfills imposed by V-EPA will mean that, from 1 July 2007, many more wastes will receive improved treatment before being sent to landfill. Stricter standards will drive industry to segregate more waste and find ways to avoid, treat and recycle wastes. Landfill bans that mandate recycling of wastes, such as steel drums, plastic containers and used oil filters, will further reduce volumes sent to landfill.

High and low-hazard manufacturing wastes disposed to landfill

Prescribed industrial wastes are legally defined in the Environment Protection (Prescribed Waste) Regulations 1998. The Government has determined not to proceed with the proposed long-term containment facility for high hazard waste at Nowingi in north-west Victoria. With the Tullamarine landfill ceasing to accept these wastes by the end of September 2009, the Lyndhurst facility, which currently operates using best-practice engineering, will remain the main facility for receiving high-hazard wastes.

Increasing costs of sending waste to landfill

Landfill levies have contributed to the reductions achieved to date. These levies are around $30 per tonne for both high and low-hazard wastes sent to landfill. These levies will increase up to fourfold to $130 per tonne for high-hazard waste from 1 July 2007, setting a higher price for industry sending these wastes to landfill. This provides a greater incentive to industry to further avoid, treat or recycle wastes and generates funds to be reinvested in cleaner technologies and recycling options. Significantly higher landfill costs makes investing in reuse and recycling options more attractive to industry in preference to sending wastes to landfill. A levy increase up to $50 per tonne for low-hazard waste will also provide an incentive to find alternative uses for these wastes. In January 2007, the Government announced further landfill levy increases, up to $250 per tonne for high-hazard waste and $70 per tonne for low-hazard waste, to take effect from 1 July 2008.

Reinvesting levy funds to assist industry to reduce waste

The landfill levies will support EPA industry programs, via the newly established HazWaste Fund, to assist industry to avoid waste or productively use wastes that cannot be avoided. The Fund will accelerate the work currently being undertaken by EPA with industry at specific industry sites, through key industry peak bodies and other related industry service organisations. Projects to avoid waste generation reuse or recycle wastes will be the prime focus of the fund.

Tracking progress in waste reductions

The measures outlined above will seek to reduce high-hazard waste by at least 30 per cent, to around 60,000 tonnes per annum during 2007—08 and about 40,000 tonnes per annum within approximately two years. EPA will report annually on the progress of the above measures in reducing the amount of high-hazard waste disposed to landfill. For further information on waste management please refer to: EPA's website, www.epa.vic.gov.au/waste/prescribed_waste.asp or contact EPA's waste team at prescribedwaste@epa.vic.gov.au or EPA's business sustainability team regarding industry support programs at business.programs@epa.vic.gov.au or sustainability case studies at www.epa.vic.gov.au/casestudies.

Comments: Australia sends their hazardous waste to landfill just as South Africa. No incineration methods have been mentioned. As can be seen the amount of a mixture of low and high hazardous waste sent to landfill has been reduced by 30 % from 122,000 tonnes to 85,000 tonnes from 2000 to 2006. There is no information about how much the high hazard waste has been reduced alone. A guess is that the biggest reduction has been on low hazardous waste, and that it will be very difficult to get a "real" reduction in high hazardous waste.

It also looks like that the Australian authorities' maybe is a bit concerned about the amount and types of hazardous waste being disposed in landfill. The Prescribed Waste Regulations were recently amended to define prescribed industrial wastes based on the hazard they pose to human health and the environment. The Environment Protection (Prescribed Waste)(Amendment) Regulations 2007 *take effect 1 July 2007 and support the recent changes to the* Environment Protection (Amendment) Act 2006*, where the Government increased the landfill levies for the disposal of prescribed industrial waste (PIW) from 1 July 2007. Different levies apply depending on the hazard of the waste.*

11.4 Selective extract from US e-CFR on the incineration of hazardous waste

This selective extracts from US e-CFR (Electronic Code of Federal Regulations) title 40, part 63, subpart EEE - National Emission Standards for Hazardous Air Pollutants from Hazardous Waste Combustors does not provide all the information in the regulation mentioned. If this information is needed, please look up the original Regulation /74/.

Who is subject to these regulations?

The provisions of this subpart apply to all hazardous waste combustors: hazardous waste incinerators, hazardous waste cement kilns, hazardous waste lightweight aggregate kilns, hazardous waste solid fuel boilers, hazardous waste liquid fuel boilers, and hazardous waste hydrochloric acid production furnaces. Hazardous waste combustors are also subject to applicable requirements under parts 260 through 270 of this chapter.

Definitions

Hazardous waste combustor means a hazardous waste incinerator, hazardous waste burning cement kiln, hazardous waste burning lightweight aggregate kiln, hazardous waste liquid fuel boiler, hazardous waste solid fuel boiler, or hazardous waste hydrochloric acid production furnace.

Hazardous waste incinerator means a device defined as an incinerator in §260.10 of this chapter and that burns hazardous waste at any time. For purposes of this subpart, the hazardous waste incinerator includes all associated firing systems and air pollution control devices, as well as the combustion chamber equipment.

Hazardous waste lightweight aggregate kiln means a rotary kiln that produces clinker by heating materials such as slate, shale and clay for subsequent production of lightweight aggregate used in commerce, and that burns hazardous waste at any time.

§ 63.1219 The replacement standards for hazardous waste incinerators

(a) *Emission limits for existing sources.* You must not discharge or cause combustion gases to be emitted into the atmosphere that contain:

(1) For dioxins and furans:

(i) For incinerators equipped with either a waste heat boiler or dry air pollution control system, either:

(A) Emissions in excess of 0.20 ng TEQ/dscm, corrected to 7 percent oxygen; or

(B) Emissions in excess of 0.40 ng TEQ/dscm, corrected to 7 percent oxygen, provided that the combustion gas temperature at the inlet to the initial particulate matter control device is 400 °F or lower based on the average of the test run average temperatures. (For purposes of compliance, operation of a wet particulate matter control device is presumed to meet the 400 °F or lower requirement);

(ii) Emissions in excess of 0.40 ng TEQ/dscm, corrected to 7 percent oxygen, for incinerators not equipped with either a waste heat boiler or dry air pollution control system;

(iii) A source equipped with a wet air pollution control system followed by a dry air pollution control system is not considered to be a dry air pollution control system, and a source equipped with a dry air pollution control system followed by a wet air pollution control system is considered to be a dry air pollution control system for purposes of this standard;

(2) Mercury in excess of 130 µgm/dscm, corrected to 7 percent oxygen;

(3) Cadmium and lead in excess of 230 µgm/dscm, combined emissions, corrected to 7 percent oxygen;

(4) Arsenic, beryllium, and chromium in excess of 92 µgm/dscm, combined emissions, corrected to 7 percent oxygen;

(5) For carbon monoxide and hydrocarbons, either:

(i) Carbon monoxide in excess of 100 parts per million by volume, over an hourly rolling average (monitored continuously with a continuous emissions monitoring system), dry basis and corrected to 7 percent oxygen. If you elect to comply with this carbon monoxide standard rather than the hydrocarbon standard under paragraph (a)(5)(ii) of this section, you must also document that, during the destruction and removal efficiency (DRE) test runs or their equivalent as provided by §63.1206(b)(7), hydrocarbons do not exceed 10 parts per million by volume during those runs, over an hourly rolling average (monitored continuously with a continuous emissions monitoring system), dry basis, corrected to 7 percent oxygen, and reported as propane; or

(ii) Hydrocarbons in excess of 10 parts per million by volume, over an hourly rolling average (monitored continuously with a continuous emissions monitoring system), dry basis, corrected to 7 percent oxygen, and reported as propane;

(6) Hydrogen chloride and chlorine gas (total chlorine) in excess of 32 parts per million by volume, combined emissions, expressed as a chloride (Cl^{-}) equivalent, dry basis and corrected to 7 percent oxygen; and

(7) Except as provided by paragraph (e) of this section, particulate matter in excess of 0.013 gr/dscf corrected to 7 percent oxygen.

(b) ***Emission limits for new sources***. You must not discharge or cause combustion gases to be emitted into the atmosphere that contain:

(1)(i) Dioxins and furans in excess of 0.11 ng TEQ/dscm corrected to 7 percent oxygen for incinerators equipped with either a waste heat boiler or dry air pollution control system; or

(ii) Dioxins and furans in excess of 0.20 ng TEQ/dscm corrected to 7 percent oxygen for sources not equipped with either a waste heat boiler or dry air pollution control system;

(iii) A source equipped with a wet air pollution control system followed by a dry air pollution control system is not considered to be a dry air pollution control system, and a source equipped with a dry air pollution control system followed by a wet air pollution control system is considered to be a dry air pollution control system for purposes of this standard;

(2) Mercury in excess of 8.1 µgm/dscm corrected to 7 percent oxygen;

(3) Cadmium and lead in excess of 10 µgm/dscm, combined emissions, corrected to 7 percent oxygen;

(4) Arsenic, beryllium, and chromium in excess of 23 µgm/dscm, combined emissions, corrected to 7 percent oxygen;

(5) For carbon monoxide and hydrocarbons, either:

(i) Carbon monoxide in excess of 100 parts per million by volume, over an hourly rolling average (monitored continuously with a continuous emissions monitoring system), dry basis and corrected to 7 percent oxygen. If you elect to comply with this carbon monoxide standard rather than the hydrocarbon standard under paragraph (b)(5)(ii) of this section, you must also document that, during the destruction and removal efficiency (DRE) test runs or their equivalent as provided by §63.1206(b)(7), hydrocarbons do not exceed 10 parts per million by volume during those runs, over an hourly rolling average (monitored continuously with a continuous emissions monitoring system), dry basis, corrected to 7 percent oxygen, and reported as propane; or

(ii) Hydrocarbons in excess of 10 parts per million by volume, over an hourly rolling average (monitored continuously with a continuous emissions monitoring system), dry basis, corrected to 7 percent oxygen, and reported as propane;

(6) Hydrogen chloride and chlorine gas in excess of 21 parts per million by volume, combined emissions, expressed as a chloride (Cl(−)) equivalent, dry basis and corrected to 7 percent oxygen; and

(7) Except as provided by paragraph (e) of this section, particulate matter in excess of 0.0015 gr/dscf corrected to 7 percent oxygen.

(c) *Destruction and removal efficiency (DRE) standard*.

(1) *99.99% DRE*. Except as provided in paragraph (c)
(2) of this section, you must achieve a destruction and removal efficiency (DRE) of 99.99% for each principle organic hazardous constituent (POHC) designated under paragraph (c)
(3) of this section. You must calculate DRE for each POHC from the following equation:

$$DRE = [1 - (W_{out}/ W_{in})] \times 100\%$$

Where:

W_{in}= mass feedrate of one POHC in a waste feedstream; and

W_{out}= mass emission rate of the same POHC present in exhaust emissions prior to release to the atmosphere.

(2) *99.9999% DRE* . If you burn the dioxin-listed hazardous wastes F020, F021, F022, F023, F026, or F027 (see §261.31 of this chapter), you must achieve a DRE of 99.9999% for each POHC that you designate under paragraph (c)(3) of this section. You must demonstrate this DRE performance on POHCs that are more difficult to incinerate than tetra-, penta-, and hexa-chlorodibenzo- *p* -dioxins and dibenzofurans. You must use the equation in paragraph (c)(1) of this section to calculate DRE for each POHC. In addition, you must notify the Administrator of your intent to incinerate hazardous wastes F020, F021, F022, F023, F026, or F027.

(3) *Principal organic hazardous constituent (POHC)*. (i) You must treat each POHC in the waste feed that you specify under paragraph (c)(3)(ii) of this section to the extent required by paragraphs (c)(1) and (c)(2) of this section.

(ii) You must specify one or more POHCs that are representative of the most difficult to destroy organic compounds in your hazardous waste feedstream. You must base this specification on the degree of difficulty of incineration of the organic constituents in the hazardous waste and on their concentration or mass in the hazardous waste feed, considering the results of hazardous waste analyses or other data and information.

(d) *Significant figures*. The emission limits provided by paragraphs (a) and (b) of this section are presented with two significant figures. Although you must perform intermediate calculations using at least three significant figures, you may round the resultant emission levels to two significant figures to document compliance.

(e) *Alternative to the particulate matter standard*.

(1). *General*. In lieu of complying with the particulate matter standards of this section, you may elect to comply with the following alternative metal emission control requirement:

(2) *Alternative metal emission control requirements for existing incinerators* . (i) You must not discharge or cause combustion gases to be emitted into the atmosphere that contain cadmium, lead, and selenium in excess of 230 µgm/dscm, combined emissions, corrected to 7 percent oxygen; and,

(ii) You must not discharge or cause combustion gases to be emitted into the atmosphere that contain antimony, arsenic, beryllium, chromium, cobalt, manganese, and nickel in excess of 92 µgm/dscm, combined emissions, corrected to 7 percent oxygen.

(3) *Alternative metal emission control requirements for new incinerators* . (i) You must not discharge or cause combustion gases to be emitted into the atmosphere that contain cadmium, lead, and selenium in excess of 10 µgm/dscm, combined emissions, corrected to 7 percent oxygen; and,

(ii) You must not discharge or cause combustion gases to be emitted into the atmosphere that contain antimony, arsenic, beryllium, chromium, cobalt, manganese, and nickel in excess of 23 µgm/dscm, combined emissions, corrected to 7 percent oxygen.

(4) *Operating limits* . Semivolatile and low volatile metal operating parameter limits must be established to ensure compliance with the alternative emission limitations described in paragraphs (e)(2) and (e)(3) of this section pursuant to §63.1209(n), except that semivolatile metal feedrate limits apply to lead, cadmium, and selenium, combined, and low volatile metal feedrate limits apply to arsenic, beryllium, chromium, antimony, cobalt, manganese, and nickel, combined.

11.5 Comparison of some of the emission values between EU and US

It is not straight forward to compare the emission values, but if we look at the following data and recalculate them to 11 % O_2, and from ppm to mg/m^3 we get the following results.

Daily average values

	EU (11 % O_2)	US (11 % O_2)
Total dust	10 mg/m^3	327 mg/m^3 (0.013 g/dscf, 7% O_2)
Gaseous and vaporous organic substances, expressed as total organic carbon	10 mg/m^3	*3,5 mg/m^3 (10 ppm, 7% O_2)
Hydrogen chloride (HCl)	10 mg/m^3	*35 mg/m^3 (32 ppm, 7% O_2)
Hydrogen fluoride (HF)	1 mg/m^3	?
Sulphur dioxide (SO2)	50 mg/m^3	?
Nitrogen monoxide (NO) and nitrogen dioxide (NO2) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	200 mg/m^3 (*)	?
Nitrogen monoxide (NO) and nitrogen dioxide (NO2), expressed as nitrogen dioxide for existing incineration plants with a nominal capacity of 6 tonnes per hour or less	400 mg/m3 (*)	?
Dioxins and furans	0.1 ng/m^3	0,08 ng/m^3

* C mg/m^3 = ppm x Mw/22.42 x p/760, 273 K/T and
Es = (21-Os/21-Om)x Em
Es= Calculated emission concentration at the standard percentage O_2 conc.
Em= measured emission conc.
Os= standard oxygen conc.; Om= measured oxygen conc.

As can be seen the some limits are higher in the EU and some are lower. However as can be seen in both regulation there are many other demands that make the picture more complete (and more complex).

12 Conclusion

In the present chapter is presented the overall advantages and disadvantages of incineration of hazardous waste.

12.1 Disadvantages

Effective incineration is complex and depends on many factors, such as: equipment and process design, process control and maintenance of the correct residence time, temperature and turbulence, type of products incinerated, and capacity and effectiveness of air pollution control devices.

12.1.1 New Pollutants, Heavy Metals and Unburned Toxic Chemicals

Public perception of incineration is largely negative, in particular in countries with experience of outdated incinerators only. However, in countries such as Switzerland, Denmark, Sweden and Norway where incineration is a well-established part of the energy generation system and where high emission standards have been achieved for some time, there is limited opposition to incineration. In South Africa there is no history of modern well-performing incinerators and public opinion is largely negative due to real and perceived threats posed by incineration to the environment and public health. The main concerns are the formation of polychlorinated dibenzodioxins and polychlorinated dibenzofurans (often referred to simply as dioxins) when chlorinated waste is incinerated. Also the releases of heavy metals, dust and other unburned toxic chemicals are of concern.

Dioxins, which are extremely toxic and persistent in the environment, are formed as the result of a reaction during the cooling of the stack gases. The formation of dioxins has been minimised in modern incinerators either by cooling down in boilers taking out the heat of the flue gas or by quenching off gases quickly to below 200 ^{o}C and the release of dioxins, heavy metals and dust are carefully controlled by passing off gases through intensive flue gas cleaning processes.

Reports of many different kinds of releases from incineration plants are in modern flue gas cleaning systems collected either in the dust filters, in the scrubber systems or in the activated carbon filters. Activated carbon filters will collect all kind of organic products, and as the activated carbon is incinerated after use, these compounds are all collected and destroyed.

High temperature incinerators are complex pieces of equipment, which require highly skilled personnel and constant monitoring to maintain stable operating conditions. Furthermore, the managers of incineration plants need to have a high moral. Therefore strong Governmental enforcement of relevant legislation in the first many years of a waste incineration plants life is advised.

The requirement for stable operating conditions is uniform to all reviewed technologies, but stable conditions are of further importance to open-processes than to closed processes. Many studies have revealed that uncontrolled release of e.g. dioxins from incineration process can be controlled although increased risks for emissions are recognised during start-up and close-down of operation. But seen in the light that incineration plants works 365 days a year and 24 hour a day, with only one or two annual stops for maintenance this problem again seems minor.

12.1.2 Residual Products

The incineration of MSW produces residual ash and flue gas containing PCDD/F. A disadvantage in the past has been the poor control of the incineration residues disposed of as hazardous waste on landfill, which may contain high levels of POPs and other toxic chemicals.

However, modern well-operated plants can be net destroyers of PCDD/Fs, with less of these chemicals existing in the facility via the stack, in wastewater and in solid residues than is introduced via the waste feed.

Consequently, PCDD/F levels in ash have reduced significantly, and are typically ≤0.02 ng I-TEQ/g in bottom ash, and less than 0.3 ng I-TEQ/g in fly ash from pollution control devices. The expectations of PCDD/F concentrations in the ash from modern, well run incineration facilities should be well within the specified limit for ash quality, namely 1 ng I-TEQ/g.

However, many *existing* incinerators do not live up to these criteria, and therefore much higher amounts of dioxins are emitted via the air pollution control residues. Furthermore, it is completely wrong if bottom ash (low dioxin content and with potential for reuse for road construction etc.) is mixed with flue gas ash with high dioxin content. All in all it seems that just as much focus must be put on lowering the dioxin content in the bottom ash as in flue gas emissions.

12.2 Advantages

Using a modern incinerator plant the process of incineration has shown to be a very useful way of transforming hazardous waste types into considerably reduced amount of environmental much less problematic compounds to be disposed of in landfills.

Incineration of organic chemical waste has the following advantages:

- Reduction of volume of waste from 100% to about 12-13% of bottom ash and 6-7% of fly ash and material from flue gas cleaning;

- Detoxification of many different toxic compounds at the same time; especially carcinogens, pathologic materials and all kind of toxic chemicals;

- Reduction of the impact on the environment, e.g. if the alternative is direct landfilling where organic and soluble inorganic compounds easy leaks out into the environment;

- Energy recovery, especially when big amounts of waste are available in a continuous stream from the waste producers.

The incineration processes destroys all organic compounds and change their dangerous chemistry radically to something less dangerous. These advantages, in combination with extensive use of waste treatment and combined energy utilisation (electricity utilization and possibly utilisation of process steam/heat) are the background for the very general use of incineration.

As shown in this report, the original problems with incineration of waste have been solved to a great extent.

- The flue gas can now a days be cleaned to an acceptable extend, much cleaner than when people are having a fire in the home stove.

- Wastewater, if generated e.g. by a wet flue gas cleaning system, is cleaned to an extent just as clean as wastewater from households. It is possible to apply semi-dry or dry flue gas cleaning, which result in an effluent-free incineration plant.

- Landfilling of residues from flue gas cleaning requires particular hazardous waste landfill sites as e.g. heavy metals and normal salts may be leached out. Many attempts to solve the problem are being made. Still the APC residues are nearly only consisting of inorganic compounds. E.g. vitrification is a possibility but at a considerable environmental cost due to the high energy requirement, reducing the net energy production of a waste to energy plant.

- If landfilling of organic hazardous waste is compared to incineration of organic hazardous waste, the amount of organic chemicals reaching the environment is often reduced about 100 fold. According to the European legislation the Incineration plants shall be operated in order to achieve a level of incineration such that the slag and bottom ashes Total Organic Carbon (TOC) content is less than 3 % or their loss on ignition is less than 5 % of the dry weight of the material.

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Annex 1: Article by Dave Llorito in BusinessMirror, July 17 2007

Monday, July 16, 2007

Waste management: legislation without understanding /33/

UPSET by the rising prices of commodities, a president—or so the joke goes—at one time asked his socioeconomic planning secretary to explain the problem. The socioeconomic planning secretary told the president that more people are buying these commodities, thus outstripping supply. “A classic example of the operations of the law of supply and demand, Mr. President,” he said. The president answered: “Then, I should ask Congress to repeal that law.”

The provisions of the country’s Clean Air Act and the Solid Waste Management Act on waste management somehow mirror this kind of joke foisted upon us by well-meaning individuals blinded by their lack of understanding of the dynamics of the policy issue. That explains why, as pointed out in last week’s editorial, we are experiencing a waste-management crisis, manifested in the accumulation of untreated, unprocessed biomedical, toxic and hazardous waste in the environment.

This lack of understanding clearly manifested itself early in the day with the passage of the Clean Air Act in June 1999, which banned incineration but allowed pagsisiga or the “traditional” small-scale burning of waste, including agricultural waste.

Analysts then expressed fears that the new law actually encouraged open burning of garbage, including toxic and hazardous wastes, since the vague definition provided by Section 20 of the Clean Air Act suggested that burning waste is actually fine, provided it is done in an open, decentralized, small-scale manner—an activity that could easily fit as pagsisiga for “community and neighborhood sanitation.”

Open burning or pagsisiga is actually an environmental planner’s worst-case scenario as incomplete combustion in this process implies that cancer-causing substances are generated right smack in the community.

Indeed, people started burning their garbage right in their backyards after the closure of many dumps, as local government units either failed to secure funds for conversion of these dumps into engineered landfills or failed to get the land where landfills could be constructed. Well, they did it because the Clean Air Act actually allowed them to do so.

Realizing their mistake, “environmentalists” and legislators tried to “correct” the issue by completely banning all waste combustion under the Ecological Solid Waste Management Act of 2000. They probably hoped that legislating away the burning of waste could banish the problem. The garbage crisis got worse, however, especially after the Metro Manila Development Authority failed to get adequate landfill spaces after the closure of the Payatas dump.

And while the brouhaha over the municipal solid-waste management is brewing, companies, hospitals and processing plants generating industrial waste, biomedical waste, and toxic and hazardous waste are either storing their refuse on-site for future disposal when a proper facility is available, or outsourcing their disposal to private contractors while hoping that such private firms have what it takes to handle them.

Looking at the actions of some "environmentalists" who lorded it over the crafting and passage of the solid-waste management law, one can't help but suspect that many of them were not doing their advocacies in good faith.

Naturally, when thermal technologies are banned, the next viable option could be engineered landfills. But when LGUs tried to look for landfill spaces, many in the same network of "civil-society" groups dabbling in environmentalism also opposed landfills, citing certain environmental risks. The only correct option, they say, is "zero waste," as if it's actually possible to do so.

Well, "zero-waste management" is actually possible in small, isolated villages producing a few kilograms of organic waste. But it certainly wouldn't work in megacities producing tons of municipal, industrial, and toxic and hazardous wastes. They missed this perspective because when legislators and "environmentalists" were crafting the laws, they didn't bother to check the markets for recyclable materials.

In fact, they didn't know at all the characteristics of Metro Manila's waste stream. They didn't know how much percentage is economically viable for recycling. They didn't know who the buyers and sellers are and how much are being transacted in these recycling markets. They simply assumed that mandating recycling and reuse would automatically solve the problem like magic. Had they known these basic facts, they would have known the enormity of the problem and acted accordingly.

And the fatal flaw is the lack of understanding value and social use of land. The Philippines is a land-scarce country. Without resorting to land-saving waste-management options offered by thermal technologies and waste-to-energy plants, Philippine cities will have to gobble up huge tracts of land for landfills and dumps, thus posing strong competition for other uses like agriculture, forestry, industry and socialized housing.

This partly explains the pervasive Nimby (not in my backyard) syndrome. Certainly, it is hard to convince communities to host a landfill or a dump, knowing that such a "special land use" would destroy land values.

That is why other countries adopt an integrated waste-management program that allows for a hierarchy of options covering waste generation (minimize, reuse, recycle); storage; collection; processing, treatment and recovery; and disposal.

For instance, if thermal facilities (assuming adequate environmental standards)

were available to handle what cannot be recycled (including biomedical, industrial and other toxic and hazardous waste), Metropolitan Manila can reduce the volume of waste by 90 percent.
The residual waste, or the ashes that could be made even safer to handle through vitrification, could be disposed of in monofills.

Compared to landfills that occupy hundreds of hectares, monofills need only a few hectares, thus saving a lot of land for other more socially beneficial uses. Equipped with liners and proper engineering design, environmental risks such as leaching could be eliminated. This way, the Nimby syndrome could be avoided.This is what land-scarce countries in Europe do. This flexibility of options is not currently available to us in the Philippines because our legislators chose to craft our policy with their eyes closed. If legislators won’t undo our mistakes, we are stuck with this garbage forever.

(Originally drafted as Editorial for BusinessMirror, July 17 2007).

Posted by Dave Llorito

Annex 2: General Information: Waste management in Germany

March 2007 /57/

Waste management has come a long way since the early 70s: for example, before the first Waste Avoidance and Waste Management Act were passed in 1972, every single town and village had its own landfill site – about 50,000 throughout Germany. During the 80s and 90s the number of landfills was drastically reduced to less than 2,000 and establishing and operating these sites was subjected to strict rules and regulations. The majority of the former landfills for domestic waste were closed down. Nowadays, only 160 landfills for domestic waste are in operation (so-called Landfill class II). The number of incineration plants, plants for mechanical-biological or other treatments of domestic waste and special treatment plants for industrial waste was raised considerably.

From the mid-80s the political concept of waste hierarchy caught on:

"Reduce, Reuse, Recover".

Product responsibility is at the heart of waste management policy in Germany. Through this the conditions for an effective and environmentally sound waste avoidance and recovery are already created in the production stage. Producers and distributors must design their products in such a way as to reduce waste occurrence and allow environmentally sound recovery and disposal of the residual substances, both in the production of the goods and in their subsequent use.

In addition to recycling metal, textiles and paper, which is already being carried out, other recyclable materials as well should be collected separately, sorted and used and thus reintroduced into the economic cycle. This idea was the basis for the Closed Substance Cycle and Waste Management Act which entered into force during the mid-90s.

Today more than 250,000 people in Germany work in waste management – from engineers and refuse workers to civil servants. There are a number of colleges which offer waste management courses and there is even special training for professions in the waste disposal sector. The annual turnover of waste management exceeds 50 billion Euro.

Today more than half of the waste from private households and production is recovered. In some areas, for example packaging, the number is as high as 80% and even 86% in the building sector. The total volume of waste which is being recovered is impressive: 28 million tonnes of domestic waste, 31 million tonnes of waste from production and trade and 162 million tonnes of construction and demolition waste. This is equivalent to the recovery of about four tonnes of waste per head in Germany. This is about the weight of four small cars.

These numbers give an impressive idea of how important environmental protection has become for the economy. It significantly contributes to the value added of national economies.

The contribution of modern waste management to climate protection is remarkable: over the last 15 years the emission of greenhouse gas pollutants from waste management was reduced by 30 million tonnes of CO_2 equivalents per year.

The federal government's environmental target is to further develop waste and closed cycle management towards materials flow management over the coming years. By strictly separating wastes, through pretreatment, recycling and the recovery of energy, Germany aims to make full use of substances and materials bound in wastes and therefore make landfilling of wastes superfluous. Successful materials management has to include production and consumption. The recycling of raw materials has to be supported while ensuring that harmful substances from waste do not reappear in new products but are safely filtered out.

Annex 3: Comments to Republic Act No. 9003, Republic Act No. 9003, “The Ecological Solid Waste Management Act"

A. Introduction

President Gloria Macapagal-Arroyo signed Republic Act No.9003 into law on 26 January 2001. Short-titled Ecological Solid Waste Management Act of 2000, it is by far the most comprehensive piece of legislation to address the country’s garbage problem /55/.

This dissection of the Ecological Waste Management Act into implementation issues seeks to present a basic understanding of RA 9003 and identify as well as anticipate possible choke points that may arise in the implementation of the law. There is also a need to look at the importance of ensuring fund allocation for its implementation and possible future scenarios.

This paper recognizes that effective implementation of the law needs to proceed beyond the ideal circumstances. If not, an end result would be a perpetuation of the problems it sought to address. It seeks not to duplicate the implementation problems encountered by another landmark law – the Clean Air Act.

Last year, Metro Manila generated an estimate of 5,948 tons of solid waste per day. Within five (5) years after the efficiency of RA 9003, approximately 1,500 tons should be diverted from simply disposable to recycled, re-used or compost products. A World Bank-funded study discovered that as early as 1982, despite a lower volume of waste, 1,839 tons could possibly be recovered. Solid waste management whose importance is directly related to public health, resource management and utilization, and maintaining a clean environment, is necessary in ensuring human development. Solid waste management benefits the population in many ways.

B. What are our wastes? Is RA 9003 comprehensive enough?

The law specifically declares in Sec. 2 that it is the policy of the state to adopt a systematic, comprehensive and ecological solid waste management system. To understand the essence of this system, it would be necessary to identify: 1) solid wastes and how the law classifies these, and 2) the limitations of the law. The following are the types of wastes identified by RA 9003:

1. Solid Wastes – all discarded household, commercial wastes, non-hazardous institutional and industrial wastes, street sweepings, construction debris, agricultural wastes, and other non-hazardous/non-toxic solid wastes.

2. Special Wastes – these are household hazardous wastes such as paints, thinners, household batteries, lead-acid batteries, spray canisters, and the like. These include wastes from residential and commercial sources that comprise of bulky wastes, consumer electronics, white goods, yard wastes that are collected separately, oil, and tires. These wastes are usually handled separately from other residential and commercial wastes.

3. Hazardous Wastes – these are solid, liquid, contained gaseous or semisolid wastes which may cause or contribute to the increase in mortality, or in serious or incapacitating reversible illness, or acute/chronic effect on the health of people and other organisms.

4. Infectious Wastes – mostly generated by hospitals.

5. Wastes resulting from mining activities including contaminated soil and debris.

With these classifications, RA 9003 is seen to be comprehensive enough in taking action on solid wastes and to some extent special wastes as outlined in the preceding list.

The law, however, does not provide exact treatment and absolute management of hazardous waste, infectious wastes or wastes resulting from mining activities.

C. Solid Waste Management System of RA 9003

The paradigm of RA 9003 is “waste is resource that can be recovered”, emphasizing recycling, re-use and composting as methods to minimize and eventually manage the waste problem.

Solid waste management starts at the point where people learn how to conserve the resources available, thus promoting sustainable development. *(Brundtland, 1987).* Awareness on how to conserve resources, as first step, is expected to reduce the volume of waste generated whether at the industrial level or household and commercial levels.

This first step will require extensive education to change the values of the people. In another study by Norconsult in 1982 showed that half of the total solid wastes generated come from households. Upon segregation, wastes are supposed to be collected and it is expected to implement 100% collection efficiency. Recyclable wastes are to be hauled and moved to stations where they shall be temporarily stored, separated, converted, or simply transferred to larger vehicles for transport.

RA 9003 identifies the following as transfer stations: buy-back centres, the materials recovery facilities, and other waste management facilities that may be developed in the future. Food, yard, and agricultural wastes shall be processed through composting and eventually distributed or used as organic fertilizers. Non-recyclable wastes shall be disposed of in sanitary landfills, controlled dumps or other waste management facilities. Throughout this system, the use of new and appropriate technology will be significant. This responsibility is vested upon the National Ecology Centre.

For one, the technology for recycling should not incur more costs than benefits in terms of income or usefulness of the recycled product, and must be of comparable quality to existing products. Another would be the shift from the use of inorganic to organic fertilizers. However, this usually affects crop yield negatively, thus it is often unacceptable to poor and marginalized farmers who comprise a large majority of the population.

Toxic Wastes, Hazardous Wastes, Infectious Wastes and other Wastes

(THWs) are recognized by the Act in subsection (j) of Sec. 17 *(The components of the Local Government Solid Waste Management Plan)*, Sec.19 *(Waste Characterization),* and Sec. 28 *(Reclamation Programs and Buyback Centres for Recyclables and Toxics).* But after determining the wastes' recyclability or non-recyclability, hazards and toxicity, the Act relegates the rest of the concern to the provisions of RA 6969.

On the other hand, RA 6969 speaks of

1) regulating, restricting or prohibiting the importation, manufacture, processing, sale, distribution, use and disposal of chemical substances and mixtures that pose unreasonable risk and/or injury to health or the environment; and

2) prohibiting the entry or even transit of hazardous and nuclear wastes, including their disposal within Philippine territorial limits.

The measure does not clearly provide the specifics on how and where to dispose wastes being generated domestically by the local industry and hospitals. Apart from 177 hospitals and industries using incinerators that are now banned in compliance with the Clean Air Act, what do we do with the wastes generated by clinics, medical facilities, manufacturing industries, and even special wastes generated by households, which comprise 1-2% of the wastes? Management of toxic, hazardous and infectious wastes is a crucial step in preventing the potent dangers these wastes may inflict on human life. Clearly a policy for its implementation must be enacted. Appropriate technology distinct from ordinary solid waste management is necessary and should be established as a solution. As a concrete suggestion, substances or raw materials used in manufacturing that result to these wastes must be banned.

D. Implementation: The Executive Branch Must Act

RA 9003 specifically directs the first step of implementation. If the intent and objectives of the law are to be achieved, the initial activities and output (Table 1) should be acted upon immediately. Although the implementing rules and regulations (IRR) may not have been drafted and promulgated, there already are targeted outputs that have to be accomplished (Table 1, Nos. 1-7). Without an approved IRR, these activities will not be implemented and thus, will cause further delays. The same thing happened to RA 8505, (The Rape Victim Assistance and Protection Act of 1998). Without an IRR, no Rape Crisis Center (RCC) has been set up two years after the passage of the law. As of 28 March 2001, former Rep. Heherson Alvarez has been appointed Secretary of the Department of Environment and Natural Resources (DENR). It is hopeful that with continued advocacy, the new secretary could immediately attend to the creation of the National Solid Waste Management Commission from where the law's implementation shall actually emanate. The Commission will be an inter-agency body headed by the DENR. The Environmental Management Bureau will serve as secretariat. There will be marginal representation from civil society, the recycling industry, and the manufacturing and packaging industries. Setting the stage for solid waste management in the country will depend largely on the DENR for the IRR, the Commission that will lay the framework, the (Local Government Units) LGUs for execution, and other public and private institutions that would encourage and sustain public participation.

E. Interventions and Institutional Mechanisms Leading to Changed Values

RA 9003 then poses a challenge. Though the mechanisms and processes leading to a systematic implementation are sufficiently discussed, there is a seething gap on how to effectively change the "people's throwing away and non-segregating behavioural pattern and the burning, dumping, and back-end practices for disposal". The challenge is to change these to patterns of resource conservation, segregation, re-use, recycling, and composting. This shift is basically attitudinal and culture-based and such task may be realized by a confluence of efforts. *Information and education* of the people is an instantaneous reply. According to RA 9003, this task is delegated to civil society and NGOs. However, for a population of 76 Million Filipinos, this is a huge task. The initial step is to educate the implementers of the law – the LGUs. In addition to this, solid waste management in the curricula of schools would enhance awareness and promote the right attitudes of the youth.

An effective and genuine enforcement of the prohibitions and penalties of RA 9003 and other related laws will also deter a portion up to a large part of the population in mindlessly throwing away and non-segregating wastes. This has been evident in local governments who have trail-blazed the path of discipline. These LGUs passed ordinances such as 1) Ordinance No. 105 of Bacolod City, prohibiting the throwing of materials in specific places and on scavenging, 2) Ordinance Nos. 4 and 1 of Olongapo City, fixing fees for the collection of waste from residential buildings and establishments, and prescribing rates for garbage collection, respectively. In essence, supplementation of LGU policies will help RA 9003 in policy enforcement and in changing behavioral patterns.

Devising market-based incentives, not just to identify markets but also to provide them for recycled materials, recovered re-usable wastes, and compost fertilizers.

F. Funding of Solid Waste Management

The initial operating expenses of Twenty Million Pesos (P20, 000,000.00) will be appropriated from the organizational adjustment fund, which will be allocated, to the National Solid Waste Management Commission, the National Ecology Center, and the LGUs. In the long term, it is projected that its annual budget shall be appropriated from the General Appropriations Act. However, the government is now experiencing a budgetary crisis, as manifested by the ballooning budget deficit. According to our country's financial managers, achieving a budget surplus is still far down the road. Therefore, this law faces the possibility of missing out on its needed appropriations. Alternative sources of funds must be sought. The Commission should recognize the possibility and start developing measures towards this end. The LGUs who shoulder the bulk of the expenses for implementation also need to establish funding mechanisms for their solid waste management plans.

Annex 4 EU Strategy paper on Dioxins & PCB

COMMISSION OF THE EUROPEAN COMMUNITIES
Brussels, 10.7.2007 COM(2007) 396 final

COMMUNICATION FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT AND THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE

On the implementation of the Community Strategy for dioxins, furans and polychlorinated biphenyls (COM(2001) 593) – Second progress report
{SEC(2007) 955}

Context
Dioxins, furans and polychlorinated biphenyls (PCDD, PCDF and PCBs) are a group of toxic chemicals that persist in the environment, bio-accumulate through the food chain and pose a risk of causing adverse effects to human health and the environment. They can cause impairment of the immune system, the nervous system, the endocrine system and the reproductive functions and are also suspected of causing cancer. Foetuses and newborn children are most sensitive to exposure. There is considerable public, political and scientific concern over the negative effects on human health and on the environment of long-term exposure to even the smallest amounts of dioxins, furans and PCBs.

A general reduction of dioxin, furan and PCB levels in the environment and humans has already been achieved over the past two decades, in particular through control of industrial emission sources, like waste incineration. In view of the persistence of these chemicals, it is however appropriate to continue working for the reduction of the anthropogenic emissions to the environment, with the goal of their continuing minimization and, where feasible, ultimate elimination. In addition, levels in feed and food should be further reduced in order to lower human exposure.

To reduce human intake, it is important to reduce the levels in the food chain since food consumption is the most important route for human exposure. Contamination of the food chain is caused by environmental contamination. Dioxins emitted to air can for example be deposited on plants or in water and taken up and accumulated by animals and fish as they feed, thereby entering the food chain. Measures to reduce the presence of dioxins, furans and PCBs therefore need to be taken both for the environment and for feed and food.
On 24 October 2001 the Commission adopted a Communication to the Council, the European Parliament and the Economic and Social Committee

setting out a Community Strategy for dioxins, furans and PCBs[7] (Dioxin Strategy). The Dioxin Strategy consists of two parts: one part containing actions for reducing the presence of dioxins, furans and PCBs in the *environment* and one part containing actions for reducing their presence in *feed and food*.

On 12 December 2001 the Environment Council adopted Conclusions on the Commission Communication, supporting the Commission Dioxin Strategy and requesting the Commission to report back on the implementation at the end of 2003 and thereafter every three years. A first progress report covering the period 2002-2003 was adopted on 13 April 2004[8].

This Communication is the second progress report summarising the activities undertaken by the Commission over the period 2004-2006 in the areas of environment and feed and food. It is supplemented with an Annex containing more detailed and technical descriptions of the developments in the different areas SEC(2007)955.

Activities undertaken in the environmental field

Dioxins, furans and PCBs are addressed under several different environmental policy areas. An area of particular importance for the period under review is the implementation of two international conventions on persistent organic pollutants (POPs). Like other POPs, dioxins, furans and PCBs are transported across international boundaries and pose a threat to the environment and to human health all over the world. This global concern is reflected by the UNEP Stockholm Convention on persistent organic pollutants, to which the Community became party in February 2005, as well as the 1998 Protocol on POPs under the UN-ECE Convention on Long-Range Trans-boundary Air Pollution.

For the EU to fully implement the obligations of the two international instruments, Regulation (EC) No 850/2004 on persistent organic pollutants[9] was adopted in 2004. The adoption constitutes a major achievement for the reduction of dioxins, furans and PCBs. The Regulation requires the Member States to develop national inventories of dioxin, furan and PCB releases and identify measures to address them. National Implementation Plans have been developed or will be developed in the near future. The POP Regulation thereby ensures that better information on national releases of dioxins, furans and PCBs will become available and that national measures to address them are being defined.

[7] COM(2001) 593 final

[8] COM(2004) 240 final.

[9] Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC, OJ L158, 30.4.2004.

The Commission has also developed a Community Implementation Plan[10], setting out actions to be taken at EU level. For the purpose of this plan, an assessment of priorities was made in order to define actions to address unintentionally released POPs, including dioxins, furans and PCBs. In particular, the Implementation Plan states that industrial sources should continue to be addressed under the existing legislative framework, including the IPPC Directive[11] and the Waste Incineration Directive[12].

Domestic sources, such as residential heating with wood and coal, are becoming increasingly important and the Commission will contribute to addressing them by promoting exchange of experience and information between stakeholders and Member States.

In addition to this general development, progress with the Dioxin Strategy actions for the environment during the period 2004-2006 has been made in a number of specific areas:

In the area of *industrial emissions* the work on identifying Best Available Techniques (BAT) for pollution prevention and control has continued and at the end of 2006 the last six of a series of 32 BREFs (BAT Reference Documents) were finalised. For some earlier adopted

BREFs a review to take into account new developments has already started, including for the cement and lime, pulp and paper and iron and steel sectors. A Thematic Strategy on *soil* protection was adopted in September 2006. It includes a proposal for a framework Directive requiring Member States to prevent soil contamination, to make an inventory of contaminated sites and to remediate the sites identified. For *waste*, the POP Regulation provides that POP contamination should be destroyed or irreversibly transformed into other substances. There are some derogations to this general rule, and in 2006 and 2007 two Regulations[13] were adopted defining limit values for dioxins, furans and PCBs for the application of such derogations.

In the framework of *public access to data* on industrial emissions, a new publicly available European pollutant register (E-PRTR) was adopted in

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[10] SEC(2007)341

[11] Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control, OJ L257, 10.10.1996, p. 26.

[12] Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste, OJ L332, 28.12.2000, p. 91.

[13] Council Regulation (EC) No 1195/2006 of 18 July 2006 amending Annex IV to Regulation (EC) No 850/2004 on persistent organic pollutants, OJ L217, 8.8.2006, p. 1, and Council Regulation (EC) No 172/2007 of 16 February 2007 amending Annex V to Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants, OJ L55, 23.2.2007, p. 1.

January 2006[14]. Compared to the present register (EPER), it has lower reporting thresholds for dioxins and furans and includes reporting of PCBs. During the period 2002-2005, two major studies were carried out to provide comprehensive information on dioxins, furans and PCBs in EU-10. The results were discussed at a workshop organised in Brussels in February 2005 during which implementation of existing legislation and increased attention to small domestic sources were identified as priorities for future work[15].

Activities undertaken in the area of feed and food
The Dioxin Strategy describes an integrated approach to legislation on feed and food to reduce the presence of dioxins, furans and PCBs throughout the food chain. This integrated approach consists of three pillars:

(1) The establishment of strict but feasible maximum levels in feed and food taking into account the results obtained in lowering the presence of dioxins in the environment.

(2) The establishment of action levels to trigger action when levels in feed or food are found clearly above background level. These action levels have an early warning function.

(3) The establishment of target levels to be achieved over time so as to bring the exposure of the majority of the European population within the limits recommended by the Scientific Committee on Food.

During the period under review, the legislation on *maximum levels* in feed and food has been updated to also include dioxin-like PCBs by the establishment of maximum levels for the sum of dioxins, furans and dioxin-like PCBs[16]. In order to ensure a smooth transition, existing maximum levels for dioxins and furans, in addition to new proposed maximum levels for the sum of dioxins, furans and dioxin-like PCBs, are maintained for a temporary period.

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[14] Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register, OJ L33, 4.2.2006, p.1.

[15] Study reports and workshop documents can be found at: http://ec.europa.eu/environment/dioxin/index.htm#enlarged_eu

[16] Commission Directive 2006/13/EC of 3 February 2006 amending Annexes I and II to Directive 2002/32/EC of the European Parliament and of the Council on undesirable substances in animal feed as regards dioxins and dioxin-like PCBs (OJ L32, 4.2.2006, p. 44) for feed; and Commission Regulation (EC) 199/2006 of 3 February 2006 amending Regulation (EC) No 466/2001 setting maximum levels for certain contaminants in foodstuffs as regards dioxins and dioxin-like PCBs (OJ L32, 4.2.2006, p. 34) for food. The latter has been replaced Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in food. (OJ L364, 20.12.2006, p. 5)

Given that the sources of dioxins and dioxin-like PCBs are different, *the action levels* set for dioxins and furans in 2002 have been maintained and separate action levels have been established for dioxin-like PCBs in 2006 simultaneously with the setting of maximum levels for the sum of dioxins, furans and dioxin-like PCBs[17]. The legislation on analytical methodology and monitoring for feed and food has been reviewed and updated in view of the inclusion of dioxin-like PCBs in the established levels and to take account of the experiences gained[18].

On non-dioxin-like PCBs, the European Food Safety Authority has performed an assessment on the risks for public and animal health of the presence of non dioxin-like PCBs in feed and food[19]. Taking into account the conclusions of this risk assessment, discussions are ongoing on the possible setting of regulatory levels for non-dioxin-like PCBs in feed and food.

Research activities

To fill some of the existing knowledge gaps dioxins, furans and PCBs have, together with other substances, been addressed in a number of research projects funded under the Sixth Research Framework Programme focussing on health effects, contamination of the food chain
and environmental aspects. Research on these substances has also been undertaken by the Joint Research Centre in the areas of soil, water, ambient air and emissions.

[17] Commission Recommendation 2006/88/EC of 6 February 2006 on the reduction of the presence of dioxins, furans and PCBs in feeding stuffs and foodstuffs (OJ L42, 14.2.2006, p. 26).

[18] OJ L364, 20.12.2006, p.32. Regulation replacing Directive 2002/69/EC of 26 July 2002 laying down the sampling methods and the methods of analysis for the official control of dioxins and the determination of dioxin-like PCBs in foodstuffs (OJ L209, 6.8.2002, p.5).

[19] www.efsa.europa.eu/etc/medialib/efsa/science/contam/contam_opinions/1229.Par.0003.File.dat/contam_op_ej284_ndl-pcb_en1.pdf

Annex 5: Danish Waste Policy

The Danish waste policy emerges from waste strategy 2005-2008 which is an important element in the total strategy for a sustainable development for the Government. The strategy has 3 purposes:

- to describe the waste policy of the Government until 2008
- to create the framework for local plans of the Municipalities and for their carrying through
- to prepare a national waste plan, which every member state in EU is obliged to do

The strategy draws up the following overall objective for the effort in the following years:

- work to prevent loss of resources and environmental impact from waste
- uncouple the raise in waste production from the economic development
- get as much environment as possible for the money

Danish waste policy comprises both prevention and handling of waste. Supreme authority in waste matters is the Danish EPA. Municipal and regional councils are in charge of the practical administration of waste management. All municipal councils survey waste amounts and draw up waste management plans. Also, it is the responsibility of municipal and regional councils that sufficient incineration and landfill capacity is available.

In Denmark, around seven kg wastes per capita are generated every day of the year. The task of ensuring collection, correct treatment and largest possible rate of recycling of this waste is heavy, but not impossible.

Experience from waste management in recent years has shown that it does make a difference to make an effort. We have achieved many fine results, but it is no secret that we are still faced with important challenges.

We have reached the overall objectives laid down in the action plans in the 1990's. For example, in 1997 total recycling was already 9 per cent above the objective for year 2000, and landfilling was reduced to a level below the objective set for year 2000.

In 1997 the Government introduced a ban on landfilling of waste suitable for incineration. This regulation has been very successful and has meant that more waste has been shifted from landfilling to incineration. When waste that used to be landfilled is incinerated, recovery of the energy contained in waste is ensured, and at the same time much waste is avoided at landfills - waste that takes up space, smells and threatens groundwater resources.

All in all, we have come a long way, but we must go further. An important target for the future is to shift waste from incineration to recycling. Incineration is better than landfilling, but a long term perspective is to recycle even more. For example, paper, cardboard, organic domestic waste, and waste electronic equipment must be recycled. We will also shift waste, for example industrial waste, directly from landfilling to recycling.

Another aspect for the future is the quality of waste treatment. We used to concentrate our efforts primarily on limiting waste arising, increasing recycling and reducing landfilling. These aspects are still important, but focus is now on more qualitative elements and utilisation of resources in waste, quality in treatment, and greater efforts for environmental contaminants /75/