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Assessment of the application and possible development of community legislation for the control of waste incineration and co-incineration

Final Report

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CONTENT

Index of Tables

Index of figures

List of Abbreviations

AEL	(BAT) Associated Emission Levels
AOX	Absorbable Organically Bound Halogens
BAT	Best Available Technique
BOD	Biochemical Oxygen Demand
BTG	Blast furnace top gas
CAFE	Clean Air for Europe
CAN	Cerium(IV)ammonium nitrate
CEFIC	European Chemical Industry Council
CEMBUREAU	The European Cement Association.
CEN	European Committee for Standardization
CEPI	Confederation of European Paper Industries
CERAME-UNIE	The European Ceramics Industries
CEWEP	Confederation of European Waste-to-Energy plants
COD	Chemical Oxygen Demand
CWI	Clinical Waste Incinerator
DOC	Dissolved Organic Carbon
EN	European Standard
ELV	Emission Limit Value
EPER	European Pollutant Emission Register
ESP	Electrostatic precipitator
EULA	European association of the lime industry
EURELECTRIC	Association of the electricity industry in Europe
EURITS	European Union for responsible Incineration and treatment of special waste
EUROMETAUX	European Association of Metals
EWL	European List of Waste
EXCA	European Expanded Clay Association
FEAD	European Federation of Waste Management and Environmental Services
FGT	Flue Gas Treatment

HM	(Heavy Metals)
HWI	Hazardous Waste Incinerator
I-TEQ	International Toxic Equivalent Concentrations
ISWA	International Solid Waste Association
LOI	Loss on Ignition
MWI	Municipal Waste Incinerator
NACE	Industry sector coding system
NMVOC	Non Methane Volatile Organic Carbon
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyls
PCDD	Polychlorinated dibenzo-dioxins
PCDF	Polychlorinated dibenzo-furans
PM 10, PM 2,5	Particulate Matter
SCR	Selective catalytic reduction
SME	Small and medium sized enterprises
SNCR	Selective non catalytic reduction
SSI	Sewage Sludge Incinerator
SYPRED	Syndicat Professionnel du Recyclage et de l'Elimination des Déchets
TDI	tolerable daily intake in (TEQ/kg body weight)
TEF	Toxic Equivalent Factor
TEQ	Toxic Equivalent Concentration
TOC	Total Organic Carbon
TWI	tolerable weekly intake (in TEQ/ kg bodyweight per week)
WHO	World Health Organisation
WID	Directive 2000/76/EC on the incineration of waste (Waste Incineration Directive)

English short names and country codes of the 27 Member States of the European Union

Short name (English)	Country code
Austria	AT
Belgium	BE
Bulgaria	BG
Cyprus	CY
Czech Republic	CZ
Denmark	DK
Estonia	EE
Finland	FI
France	FR
Germany	DE
Greece	EL
Hungary	HU
Ireland/Eire	IE
Italy	IT
Latvia	LV
Lithuania	LT
Luxembourg	LU
Malta	MT
Netherlands	NL
Poland	PL
Portugal	PT
Romania	RO
Slovakia	SK
Slovenia	SI
Spain	ES
Sweden	SE
United Kingdom	UK

1. Executive summary

The aim of Directive 2000/76/EC on the incineration of waste (WID) is "*to prevent or to limit as far as practicable negative effects on the environment, in particular pollution by emissions into air, soil, surface water and groundwater, and the resulting risks to human health, from the incineration and co-incineration of waste*" [WID Article 1].

The objective of the study is to provide the Commission with an assessment of the implementation of the WID, proposals for amendments of the Directive and assessments of those possible amendments. This is to provide a basis of the review foreseen by Article 14 of the WID, to facilitate possible further development of the Directive and to provide an input in the broader context of the review of the IPPC Directive and related legislation.

This report presents the results in three general sections:

- Information on the implementation of the WID in the Member States,
- Case studies on costs and benefit of the implementation,
- Options for amendment of the WID

1 ➔ Implementation in the MS

In total 1444 incineration and co-incineration plants have been reported (see following table for details).

Table 1: Overview: Number of plants

	Number of plants	Amount of waste	Data availability
dedicated waste incineration	595 plants	~60 million tonnes	Data from 21 Member States
co-incineration	849 plants	>13 million tonnes	Data from 13 Member States

Based on a number of expert interviews, discussions and plausibility checks with literature data it can be estimated that about 30% of the installations that co-incinerate waste have not been reported. Identification of plants where the WID had to be applied when it entered into force and ensuring that the permits were issued in time was done by the Member States mostly in the course of routine updates of the permit or granting of IPPC permits or was achieved by informing the competent (often regional) authorities about the need to consider the WID requirements for appropriate plants. A feedback mechanism about the details of the permits from the regional to the national level is not established in some Member States, and this has made accessing data from certain MS more difficult.

The application of the WID for specific types of installations has been analysed for small waste oil burners, thermal soil cleaning, thermal cleaning of work pieces and the use of high calorific wastes in the ceramic industry. Here, as well as in cases where waste is temporarily co-incinerated, the Member States' approaches show a heterogeneous picture resulting from different interpretations of the WID.

Stricter air emission limit values have been imposed to a number of plants and as a general rule for the incineration and co-incineration of waste in at least 3 Member States. Parameters affected are dust, HCl, HF, SO_2, NOx and Hg.

At least 13% of the plants have been granted exemptions from operating conditions, most often minimum temperature and residence time.

Exemptions from measurement requirements as provided by the WID have been reported for ~980 cases (approximately 25%[1] of the plants), most of them for HF, HCl and SO_2 (no continuous measurements) and few for heavy metals and PCDD/F. Most exemptions within the possibilities given by the WID were granted in the lime and cement industry and for dedicated incineration plants (which is proportional to the high number of plants in these sectors).

Additional monitoring of PAH emissions to air has been reported for three Member States and a number of individual plants in other Member States.

Overall, the analysis of the implementation of the WID revealed that the permitting in most Member States has been performed with a high degree of compliance at least for the reported installations. Co-ordinated permitting of installations according to WID and IPPCD was accomplished in the Member States.

Two issues of concern have come out of the reported data.

Firstly, some 150 to 200 exemptions which seemed to go beyond the exemption clauses of the WID have been reported.

[1] Some double counting could not be avoided as some plant measure periodically and continuously

Secondly, the requirements of Art. 12(2) of the WID on the publication of information about incineration and co-incineration plants seem to be fulfilled by only ~⅓ of the Member States. Therefore, centralised (electronic) management of information about permitting situation of installations is, however, seen as an approach to improve the knowledge of national institutions about the implementation of the WID significantly.

2 ➔ Case studies

A number of case studies on costs and benefits of the WID implementation have been performed that analysed the effect of the WID on the cost situation and environmental performance of individual installations. Focus has been set on measures for the reduction of emissions triggered by the WID requirements, the resulting environmental and health effects and cost effects of measures for the monitoring of air emission. Additional, mostly "indirect" effects like benefits improved energy efficiency, has not been included in the calculations.

The analysis showed that generally relevant environmental benefits have been achieved with moderate costs. The following table provides an overview of the results.

Table 2: Overview: Cost - benefit analysis results

Type of installation	Sum of monetised health & environmental benefits in €/y	total costs for WID compliance in €/y
Hazardous waste incinerators	7 000 to 260 000	80 000
Municipal waste incinerators	2.5 million to 7 million	600 000 to 7.4 million
Cement plants	2.2 million to 7.4 million	200 000 to 1.3 million
Lime plant	-	35 800
Power station	315 to 675 000	65 000 to 3 million
Expanded clay plant	600 000	660 000

The big range of costs results from the fact that

- sometimes a major revamp of the installation was necessary and sometimes only small changes,
- sometimes the emission level before the implementation of the WID was significantly higher than the WID ELV and sometimes already very close to the WID requirements and
- the sizes of the plants differ.

3➔ Options for amendments

The impact analysis (partly in conjunction with analysis of technical feasibilities) carried out for possible amendments of the WID showed the following results:

- The analysis of impacts of further exemptions from monitoring requirements of the WID shows that further exemptions have a potential for cost savings with minimal additional risks of increased environmental impacts. Compared to the overall cost situation of incineration and co-incineration plants the potential cost savings are, however, relatively small.
- If dioxin-like PCB would be included in the requirements of the WID for PCDD/F emissions (ELV of 0.1 ng TEQ/m^3) it has to be taken into account that this would imply a factual decrease of the ELV for PCDD/F. At the same time current TEQ for PCDD/F will need to be reconsidered. The available data basis is too limited to allow the determination of a revised ELV that includes dioxin like PCB. A separate monitoring requirement in the WID for these compounds could result in a much improved data basis that could be used in a future review of this issue in the WID.
- The analysis of the technical feasibility of continuous PCDD/F monitoring (sampling) revealed that the techniques are very much advanced, although some issues exist as regards their compliance with the European standard. The analysis of impacts showed environmental and social benefits. The economic impacts on affected industries might be significant for installations that use just small amounts of waste. Existing and possibly extended possibilities for exemptions from monitoring requirements could limit this problem.
- Continuous monitoring of mercury is already implemented in some Member States and for several plants. The analysis of possible impacts showed best results for the option where continuous monitoring is generally required by the WID for the majority of installations whilst taking into account existing and possible future exemptions from monitoring requirements.
- The adaptation of the emission limit for NO_x for existing cement plants co-incinerating waste to the level of the limit for new cement plants was proven to be technically feasible. This would result in some additional economic burden for the sector, but this effect would be clearly exceeded by the benefits for human health and environment.
- The impact analysis regarding the use of high calorific waste in blast furnaces showed that, as an alternative to emission monitoring for certain pollutants, applying a waste input based approach could have certain benefits.

Several other issues have been raised by stakeholders with the implementation and application of the WID requirements. Most of them regard the need for clarification of definitions, scope related aspects and monitoring requirements. Several of these issues might not need changes of the text of the WID but might already be solved by further guidance on the implementation of the Directive.

2. Implementation of the WID in the Member States

2.1. Introduction

Following chapter summarises the information about the co-incineration and incineration practice in the European Member States. It is structured according to the sectors.

Chapter 2.2 explains the methodological approach taken for the data collection and describes the contributions received from stakeholders.

Chapter 2.3 describes the information received from the Member States with regard to the general implementation of the WID. Chapter 2.4 presents information with regard to the implementation of the WID in dedicated incineration plants and the implementation of BAT. Chapter 2.5 summarises the information gathered for the co-incineration sector.

Chapters 2.6 and 2.7 contain a summary and the conclusions on implementation.

2.2. Methodological approach

2.2.1. Data collection

Experience with similar projects in the past showed that in most of the cases the required information is not easily accessible at central national points. In addition it had to be taken into account that some of the information required in the course of this project is exclusively available on the level of individual permits.

Thus a differentiated approach of distributed data collection was chosen aiming at reducing the necessary efforts for the single institution:

a) The questionnaire for the Member States (see annex 1 to this report). It comprises three parts. Part one covers general implementation issues and the number of and type of co-incineration plants in the respective Member States. Part two covers the application of exemptions and additional requirements only for the co-incineration sector excluding the cement and lime industry. Part three covers the application of Article 12(2) excluding the cement and lime industry. Subsuming it excludes incineration in dedicated waste incinerators and certain topics of co-incineration in cement and lime kilns. With this, a large number of installations were excluded from that questionnaire leading to reduced efforts for the authorities. The questionnaire was sent to the national authorities of all 27 Member States on 28th December 2006 announcing end of January as the deadline of the first part of the questionnaire and end of February as deadline for the second and third part.

b) In parallel, information about dedicated waste incinerators has been requested from the European associations CEWEP (dedicated waste incinerators) and EURITS (hazardous waste incinerators) which cover more than 80% of the incineration plants operating in the European Union. Information about cement and lime kilns has been asked from the respective associations CEMBUREAU and EULA

The respective questionnaires are available in annex 1 to this report.

c) In addition to the data on co-incineration requested from the Member States, experts from the following industry sectors have been contacted in order to get a detailed data on the issue of co-incineration in their industry sector:

- Power plants
- Non ferrous metal industry
- Ferrous metal industry
- Ceramic industry
- Paper industry
- Chemical industry

Following European Associations were contacted in the context of the co-incineration of waste:

- EURELECTRIC
- EUROMETAUX
- EXCA/CERAME-UNIE
- CEPI
- CEFIC
- FEAD

In order to cope with the expected amount of data software tools based on the questionnaires were developed for the compilation of the stakeholder contributions (see Annex 2).

2.2.2. Received information

CEWEP submitted detailed answers for eight Member States: Czech Republic, The Netherlands, Finland, France, Germany, Hungary, Portugal and Sweden.

Eurits submitted information for nine Member States: Austria, Belgium, Finland, France, partly for Germany, Hungary, Poland, Sweden and the UK. The data of Eurits is not covering all hazardous waste incinerators as Eurits members are only merchant hazardous waste incinerators and not the incinerators dedicated to a particular industrial company.

In a second round also Member States were asked for information on the dedicated incineration sector: Replies are available for Latvia, Lithuanian, Romania, Slovak Republic, Slovenia and the UK. In addition some general information has been made available with the voluntary submission of the questionnaire of Commission Decision of 20/II/2006 by the UK.

The following list summarises the answers to the questionnaire sent out to the Member States.

Table 3: Overview of the Member States responses to the questionnaire

Member State	Status
Austria	Answers to questionnaire partly received.
Belgium-Wallonia	No information received
Belgium-Brussels	No information received
Belgium-Flanders[2]	Answers to questionnaire partly received.
Bulgaria	Answers to questionnaire partly received.
Cyprus	Answers to questionnaire received.
Czech Republic	Answers to questionnaire received.
Denmark	Answers to questionnaire partly received.
Estonia	Answers to questionnaire received.
Finland	Answers to questionnaire received.
France	Answers to questionnaire partly received.
Germany	No information received
Greece	No information received
Hungary	Answers to questionnaire received.
Ireland	Answers to questionnaire received.
Italy	Answers to questionnaire partly received.
Latvia	Answers to questionnaire received.
Lithuania	Answers to questionnaire received.
Luxembourg	Answers to questionnaire received.
Netherlands	Answers to questionnaire partly received.
Malta	No information received.
Poland	Answers to questionnaire partly received[3].
Portugal	No information received.
Romania	Answers to questionnaire partly received
Slovakia	Answers to questionnaire received
Slovenia	Answers to questionnaire received.
Spain	Answers to questionnaire partly received
Sweden	Answers to questionnaire partly received.
UK	Answers to questionnaire received.

[2] When Belgium is mentioned in this report, only the Flemish region is meant unless otherwise stated.

[3] Information received on 06.06.07 in Polish. An internal translation was used for the following chapters.

Answers to the questionnaire are missing completely for Belgium-Walloon and Brussels region, Germany, Greece, Malta and Portugal. For some German plant types we received selected information from the industries directly and incorporated it below. Because of the expected high relevance for the co-incineration sector, a meeting with the German environmental agency was carried out in June.

In case of Spain only 6 of 19 regions have replied to the questionnaire. For the Netherlands seven of the 12 provinces have answered. Most of them are the competent authority for large combustion plants (> 50 MWth). The Dutch communities being the authority for the small plants were not asked for input by the Dutch Authorities.

Cyprus, the Czech Republic, Romania, Bulgaria and the Slovak Republic indicated to have co-incineration in the cement and/or lime industry and therefore did not respond to some parts of the questionnaire. They answered partly with regard to the cement and lime industry (see chapter 2.5.1). According to Maltese authorities no co-incineration is carried out on Malta[4].

Denmark, Belgium-Flemish Region and Latvia did not respond to the second part of the questionnaire asking details about the permitting situation.

Additional information was provided by the industry associations. For details of the approach taken for the collection of information see chapter 2.2.

CEMBUREAU delivered aggregated information and Luxembourg, Cyprus, Lithuania, Slovenia, Hungary and the UK delivered some information regarding their cement sector.

For the lime plants, based on the data made available for the Cement and Lime BREF revision process, the relevant information was put together by Ökopol and commented resp. updated by EULA.

Additional information about the cement and lime sector was also provided by some Member States.

EXCA and CEPI submitted data on the number of plants (CEPI for 13 Member States) and some other topics.

From EURELECTRIC only information about two plants in one Member State was made available.

CEFIC, FEAD and Eurometaux did not submit information based on the questionnaires.

The information collected from the Associations and the Member States have their main shortcomings concerning completeness. For both sources the quality of the information received differed to a vast extent.

[4] pers. com. Maltese Ministry, 20.08.2007

The information collected from the Member States has its shortcomings due to the fact that permitting is often done on a more regional level and the information is only partly available at the national level the questions relating to the detailed permitting situation were often not answered.

The shortcomings of the association data is mainly due to the fact that the national members of the European associations usually do not cover all of the plants situated in one country.

Therefore all aggregated values have to be considered as the lowest value and it has to be assumed that in reality the value is higher.

2.3. General implementation of the WID

The following chapters summarise the outcome from the data collection via questionnaire.

2.3.1. Identification of existing incineration and co-incineration plants

The Member States have been asked via questionnaire: *"How were existing incineration and co-incineration plants to which the Waste Incineration Directive had to be applied identified?"*

Answers to this question were received from 21 Member States: AT, CY, CZ, DK, EE, FI, FR, HU, IE, IT, LV, LT, LU, NL, PL, RO, SK, SI, ES, SE and UK. Most of them indicated that they already knew the relevant installations.

Three Member States employed national databases for identification (AT, FI, SK). In most Member States those installation have already been licensed or permitted due to a different legal requirement (CZ, EE, IT, LV CY, DK, ES, IE, UK). In the UK and Ireland the permitting according to the IPPC Directive identified the plant falling under the WID. In Cyprus and Latvia those installations had already air pollution permits.

France conducted an inquiry, Ireland requested a permission renewal of the IPPC plants and the Netherlands communicated actively with the respective authorities. Slovenia identified the installation during inspections and Hungary during the licensing procedure.

The answers of Lithuania, Sweden and Poland could not be evaluated.

2.3.2. Enforcement of the requirement for the plants to obtain permits by the due dates

The Member States have been asked in the questionnaire: *"How was the requirement for plants to obtain permits by the due dates enforced?"*

Answers were received from 21 Member States: AT, CY, CZ, DK, EE, FI, FR, HU, IE, IT, LV, LT, LU, NL, PL, RO, SK, SI, ES, SE and UK. Most of them indicated that they enforced the requirement to obtain permits by the implementation/transposition of national legislation (UK, LV, IE, AT, CZ, FI, SK, HU, FR, RO). In Latvia the WID was implemented/enforced through the IPPC Directive. In the UK the WID and IPPC Directive are implemented through an existing Pollution Prevention and Control regime.

Slovenia and Austria granted transitional compliance periods for complying with WID requirements. Luxembourg granted provisional permits for waste input.

Lithuania, Estonia and France informed via letters either the regional authorities (FR) or the plant operators (LT, EE) about the WID requirements and deadlines.

In Denmark and Slovenia the update of the permission was obligatory at a given date. The Slovenian companies had to prove their WID compliance in order to receive a new one.

Sweden granted general permission at given date. Specific permitting was only needed when the plant had to make significant changes.

In Cyprus the permits expired automatically and their renewal included WID/IPPC provisions.

Spain stated that permits are regularly renewed. No further details were given.

In Luxembourg the permits of all plants were reviewed according to the WID requirements.

The Austrian authorities carried out a specific procedure if new permits according to WID had an impact of neighbours; otherwise reporting to the authority was considered as being sufficient. In addition local authorities were requested by the Ministry to carry out controls.

The answer of Poland could not be evaluated.

2.3.3. Approach taken to application of the WID to specific installations

The Member States have been asked in the questionnaire:

"If existing in your country, please describe the approach taken to application of the Waste Incineration Directive concerning:

- small waste oil burners (e.g. used in motor garages)

- thermal cleaning of equipment or soil

- the use of waste in ceramic kilns (e.g. paper sludge, waste wood)"

Answers were received from 21 MS: Austria, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, UK,

Italy answered that "no exemptions are foreseen". No further clarification was provided.

In Cyprus these installations do not use waste and are therefore not permitted according to the WID.

Romania, France, Ireland, Hungary, Poland, Netherlands and Austria replied in a more general way: In the Netherlands the WID is not applied as the above mentioned installations practise "reuse". According to Ireland hazardous waste/ waste oil burning requires licensing, but no licenses have been obtained. In Austria there are not exemptions possible in the national WID implementation for these cases. France indicated that some of these installations are regulated by regional ordinances. All Romanian facilities that incinerate waste have to comply with the requirements of Waste Incineration Directive and have to obtain a permit for this activity. The respective Hungarian Ministerial Decree covers all types of waste incinerators as stipulated in Directive 2000/76/EC. The Polish regulations do not incorporate any specific requirement for the plant types.

Specific answers were received from Lithuania, Bulgaria, Finland, Slovenia, Spain, Slovakia, Sweden, Luxembourg, Czech Republic, Denmark, Estonia and the UK. Their statements follow below.

2.3.3.1. Approach taken to application of the WID to small waste oil burners

The WID is applied in three Member States (Slovakia, Lithuania and Slovenia). The other Member States have answered as follows:

Estonia answered that waste oil burning is prohibited in their country. In Luxembourg and Finland waste oil burning is no allowed in installations with a capacity below 3 MW (LU) resp. 5 MW (FI). In the Czech Republic, Sweden and Spain[5] small waste oil burners do not exist. Denmark did not submit any information about this kind of installations within their country. Bulgaria answered that the incineration of waste oils is done according to their specific waste incineration regulation.

In the UK these installations are subject to a case-by case assessment. UK provided additional background information:

“The definition implies that an “incineration plant” will have a degree of technical sophistication. There is a diversity of devices in which waste is burnt, and regulators must therefore consider each type of device on a case by- case basis to assess whether it may be “incineration plant” for the purposes of the WID. A device which does nothing more than provide physical containment for what would otherwise be an open bonfire lacks the necessary degree of technical sophistication. But devices providing more than that – for example, fan assisted air flow controls – may be “incineration plant” for the purposes of the WID.” [DEFRA 2006][6]

2.3.3.2. Approach taken to application of the WID to thermal cleaning of equipment or soil

Soil cleaning

In Denmark and Sweden soil cleaning installations exist and they fall under the WID. In France one installation is falling under the WID.

In the UK the WID is not applied for “some processes involving thermal treatment” since their purpose is cleaning rather than incinerating.

In Bulgaria, Czech Republic, Estonia, Lithuania, Luxembourg, Slovenia and Spain soil cleaning installations are not existent. Estonia and Slovenia specified that the WID would apply if installations were available in their countries.

The Slovak Republic and Finland did not submit particular information about soil cleaning installations.

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[5] in 6 out of 19 regions of Spain

[6] Department for Environment, Food and Rural Affairs (DEFRA), Guidance on Directive 2000/76/EC on the incineration of waste, Edition 3 June 2006, London

Cleaning of equipment

Lithuania, Luxembourg, and Spain indicated that installations for cleaning equipment do not exist in their country.

Bulgaria, Czech Republic and the UK stated that the WID is not applied for such installations. The UK stated as a reason for this procedure that their purpose is cleaning rather than incinerating.

In France one installation is falling under the WID.

In the Slovak Republic and in Slovenia specific emission limit values are applied for such installations. Slovenia has indicated the details of these requirements.

Table 4: Slovenian ELVs for stationary source

	Limit value until 31.12.2010	Limit value from 1.1.2011
Total dust	***50 mg/m^3 ****150 mg/m^3	*20 mg/m^3 **150 mg/m^3
Organic substance, as total carbon Limit mass flow Limit concentration	-	0,1 kg/h 20 mg/ m^3
SO_2 Limit mass flow Limit concentration	1.800 g/h 350 mg/m^3	1.800 g/h 350 mg/m^3
NO_x Limit mass flow Limit concentration	1.800 g/h 350 mg/m^3	1.800 g/h 350 mg/m^3

* at mass flow of the total dust which exceeds the limit value of mass flow of the total dust which is 0,2 kg/h
** if the mass flow of total dust is equal or less than limit mass flow of total dust of 0,2 kg/h
*** at mass flow of total dust, which exceeds the limit value of total dust which is 0,5 kg/h
**** if the mass flow of the total dust is equal or less than the limit mass flow of the total dust which is 0,5 kg/h

"The calculated content of oxygen is 11%. Monitoring requirements depend on the mass flow of the substance (in main cases it has to be carried out periodically 1/3 years; 1/year for parameters which 5x exceed the limit mass flow; permanent monitoring is required in cases when the value of the particular parameter as prescribed for the continuous measurement is exceeded. Also other parameters have to be monitored in cases when they are found in the significant amounts[7]."

Denmark, Estonia, Sweden and Finland did not submit particular information about installations for cleaning of equipment.

[7] Email by Slovenian authorities, 18.05.2007

2.3.3.3. Approach taken to application of the WID to the use of waste in ceramic kilns (e.g. paper sludge, waste wood)

In Lithuania, Spain, Estonia and Sweden, the WID applies to ceramic kilns combusting waste.

In the Czech Republic and Slovenia the WID is not applied since the "use of waste in ceramic kiln is mentioned as treatment such as D9 (for sludge) or R5 (for waste wood, paper etc.) and not as incineration or co-incineration" (SI) and "paper sludges and waste wood (unpolluted) are used as raw material for the production of porous perforated bricks".

Belgium stated that plants using paper sludges from recycling of paper waste are considered as co-incineration plants as Decision 2003/33/EG on landfilling states that waste with a loss of ignition of 10 % and TOC 6 % is considered to be combustible.

In Luxembourg and the UK such installations do not exist.

Finland and Denmark did not submit particular information about ceramic kilns using waste.

2.3.4. Periodical co-incineration of waste

The Member States have been asked in the questionnaire:

"Do the emission limit values (ELV's) for co-incineration plants (in particular from plants like under 3a) always apply or only during those periods when waste is co-incinerated?"

Replies from 18 MS: Austria, Cyprus, Czech Republic, Denmark, Estonia, France, Hungary, Ireland, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, UK,

Slovenia, UK, Cyprus, France, Hungary, Ireland, Poland, Slovakia, and Lithuania indicated that the ELV of the WID only apply when waste is co-incinerated. Ireland, Lithuania and Poland apply different ELVs when no waste is incinerated.

In Austria[8], Netherlands, Sweden, Spain and Romania the ELVs of the WID always apply also when no waste is incinerated.

In Denmark the application depends on the frequency of waste co-incineration.

The answers of the Czech Republic, Estonia and Italy could not be evaluated.

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8 According to Austria two sets of ELV "would render the reasonable control impossible" and "would lead to the fact that the annual report according to Art. 12 para 2 would miss explanatory value."

2.3.5. Problems experienced with the implementation of the WID

The Member States have been asked in the questionnaire:

"Please describe any problems experienced in the implementation of the Directive (e.g. uncertainties in interpretation, technical difficulties), and how you overcame these problems."

This section summarises the answers given to this question by the Member States. Considerations will be made in the chapter 4.1, where also the input from the other stakeholders is included.

Answers were received by 20 Member States: Austria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Hungary, Ireland, Italy, Latvia, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, UK.

Cyprus, Czech Republic, Estonia and Hungary did not indicate any specific problems.

Romania indicated technical problems regarding emissions' monitoring, especially for metals and dioxins as state laboratories have not yet all relevant analysis equipment.

Several contributions asked for clarification of definitions for wastes mentioned in Article 2.2 of the WID and for exclusion of further wastes (animal fats (FI), horse manure (FI), straw & wood chips from stables (FI), the Definition of animal carcasses (UK), Vegetable waste from the food processing industry (UK), Food processing industries (UK), Wood waste (UK), Fibrous vegetable waste (SI), Radioactive waste (UK), Incineration of residues from bio-fuel production processes (LV).

Member States also raised a number of issues with the implementation of the WID for certain processes:

- Waste incineration of paper installation with a capacity lower than 50 MW with waste being
  - out of the WID scope,
  - produced on site and
  - having a low calorific value (fibrous vegetable waste) (SI),
- Paint shops & precious metal recovery (SI).
- small scale and combined plants (IE)
- co-incineration when fly ash/FGT sludge is re-injected in LCPs (DK)
- high temperature drying of wet waste (CZ)

Contributions were received that highlighted the difficulties to decide on whether a waste is to be seen as incinerated/co-incinerated in a process or whether the use of the waste in the process is to be seen as material recovery from raw materials (e.g. waste streams containing plastics in metallurgical processes, wastes with a high mineral content and low organic portion in the cement industry, mixed paper/plastic sludge to be used as expansion agent in brick and clay industry or the use of high calorific waste in blast furnaces.)

Furthermore following difficulties have been mentioned:

- Austria stated that "Art. 8 Water discharges - A problem is seen in the distribution of the responsibilities between the operator of the incineration plant for off-site water treatment plants and the other operators. Art. 11 Measurement requirements - If a plant consists of more than one line (with the same or with different waste input) and/or more than one flue-gas-cleaning (chimneys), it is not clear how many sets of limit values shall be obligatory and how many measurements should be taken. Is an average value possible in those cases? What is the sufficient content of the annual report? Art. 13 Abnormal operating conditions - this system should be revised, as it is difficult to understand and especially inappropriate for the exceeding of water limit values."
- Art. 6 (1) correct implementation of limit values for TOC etc is unclear (SK);
- Art. 11(11), Annex III 3 Consideration of the confidence levels (FR);
- Article 13 Denmark: "In article 13(3) it is unclear which limit values shall form the basis for measuring excesses for the four-hour period, as the air emission limit values in annex V are either daily average values or half-hour values.
- In article 13(4) it is unclear whether the dust ELV may be touched every half hour during the four-hour period, and it is unclear what CO and TOC values may not be exceeded."
- Art 13(3) Difficulties in calculating the max. time when ELV are exceed (FR);
- The Netherlands mentioned that "Co incineration plans have to deal with the IPPC-directive, different BREFs and also the WID. The emission levels are not the same as the BAT associated emission levels. Levels and Performance Rates for Combustion Exhaust Gas Treatment in the Chemical Sector (table 4.11 BREF CWW). (due to oxygen content)"
- Measurements, self-control, compliance (ES);
- According to Luxembourg the TOC ELV for cement plants as required by Annex II.1.2.TOC is too strict
- The missing differentiation of wastes and their characteristics was criticised by Poland. According to them it is not clear why the same ELV apply for wastes like animal and bone meal and plywood used within the processes, in particular since some of those wastes reduce the amount of certain emissions

2.3.6. Areas suggested for amendment of the Directive

The Member States have been asked in the questionnaire:

"Please describe any areas in which you suggest that amendment of the Directive should be considered, giving the reason and data behind your suggestions."

13 Member States answered Austria, Belgium, Czech Republic, Denmark, France, Ireland, Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden, UK.

2.3.6.1. Article 2 Scope and Article 3 Definitions

The exclusion of following wastes from the scope of the WID has been asked

- animal fat (AT),
- horse manure (AT, SE),
- explosives (SE),
- tallow (SE),
- animal by-products (SI)
- meat and bone meal (PL).

Romania had asked for clarifications which wastes are covered by the WID and which by Regulation 1774/2002 on animal by-products. Poland wished for inclusion of meat and bone meal in regulation 1774/2002 and emission regulations for biomass.

The Netherlands mentioned that it is unclear which gaseous wastes are included resp. excluded from the scope.

Belgium proposed to introduce concentration figures to determine when the WID can be applied to waste wood (e.g. for halogens, heavy metals). Belgium uses figures which are based on the German waste wood ordinance.

Austria wished for special provisions for small waste amounts and Ireland suggested a revision of Article 2(2) according to the changes of the WFD.

Sweden demanded a clarification on the term "abnormal operating conditions" which title Article 13 and according to the UK a definition of the term "Breakdown" as mentioned in Article 13 (2) is necessary.

The Czech Republic, Ireland, Sweden and Belgium mentioned that certain clarifications on the Definition of (co-)incineration plant would be welcomed. All MS mentioned this with reference to pyrolysis /gasification processes. The Czech Republic mentioned also plasma processes in relation with the definition of (co-)incineration.

Belgium proposed to introduce criteria for the combustion of waste like the TOC or loss of ignition in order to avoid that all kinds of techniques are labelled as combustion/incineration techniques.

The Czech Republic proposed to incorporate specific configurations for gasification/pyrolysis for certain processes like biomass with a stable composition and tyres producing gas which is marketable. For them also the definition of "subsequently incinerated" in Article 3(4) is unclear concerning time and place.

2.3.6.2. Article 6 Operating conditions

According to Sweden the TOC in bottom ashes tailored for household waste and the need for this requirement is questioned. In the view of Sweden strict CO and Air-TOC values are sufficient to secure good combustion conditions.

Regarding Article 6(4) UK finds that "The WID requirement for incineration plants that the amount of residue and TOC level is not increased is unenforceable. For the operator to prove this conclusively, the plant has to be both at normal and derogated conditions which is impossible. Similarly, the last sentence of paragraph 2 of Art 6(4) is confusing and not needed – all WID conditions must be complied with, not "at least the provisions for…total organic carbon and CO…".

2.3.6.3. Article 8 Water discharges from the cleaning of exhaust gases

Belgium noticed the need of a mixing rule also for water discharges from the cleaning of exhaust gases. In particular for metallurgical processes as their heavy metals originate from the process not from the waste. The UK uses the mixing rule already in combination with Article 8.

2.3.6.4. Article 11 Measurement requirements

The UK proposed to loosen the measurement requirement of Article 11(2) for smaller plants and proposed also to allow them periodic instead of continuous monitoring according to Article 10.

Austria proposed to include exemption possibilities if specific parameters are not relevant in the waste composition. As an example the production of heat energy by incineration of edible waste oils was mentioned. The Slovak Republic mentioned a similar example and proposed to review and reduce the monitoring requirements. Belgium noticed the same issue with regard to Cl but has posed the question how to deal with it. The UK mentioned also that monitoring of substances which are not present in the waste stream is superfluous.

Denmark agreed in stating that “in some cases the provisions of the directive are too detailed, e.g. for burning waste which does not contain heavy metals or does not produce significant amounts of acid flue gas.”

Article 11 (2) a: Sweden finds the continuous measurement of TOC unnecessary and mentioned that the requirements for continuous measuring are not adapted to batch processes as carried out e.g. in the ferrous and non ferrous metal industry. Belgium agreed in so far as they would like to know how to deal with Batch processes with regard to monitoring.

Article 11(2): a review and reduction requirements for monitoring is demanded by the Slovak Republic for hospital waste incineration plants due to high costs of the requirements.

Article 11 (3): According to the UK computational fluid dynamic packages should be accepted. They also question the necessity of the minimum residence time and demand the schedule of the Commissions assessment as indicated in Article 11 (7). In connection with Article 11(7) the possible incompatibility with the measurement requirements of Article 11(13) was mentioned.

Article 11(11): the Netherlands state that the indicated period is too short and should be excluded from the WID due to the requirement as specified in EN 14181. The UK demands a definition of a valid "1/2 hour" when the continuous emission measurement is offline and is asking whether calibration and zero-drift checking is to be included in the disallowed values.

Article 11 the Czech Republic wished for a clearer definition of the measurement requirements in connection with Annexes II, III and V.

Other topics

According to Belgium “certain waste categories can be co-incinerated in a diesel-engine or stationary engines (e.g. used frying fat or oils)

• The WID states that waste should be incinerated at a temperature of 850 °C during at least 2 seconds (article 6 §2). This is not always possible.

• continuous measurement : certain engines will be fed with one specific waste stream. Is it necessary e.g. for a mobile engine to have the obligation to do the continuous measurements (e.g. in driving busses)?

• certain emissions parameters. The WID says emission values have to be according to annex II. However technically it is not always possible to satisfy the same emission values for an engine as for a waste incineration plant. “

Austria requested a harmonisation and structuring of the reporting data of Article 12(2) in an Annex of the WID.

Article 13 (3) according to the UK batch plants like gasification/pyrolysis plants have large difficulties to comply with a 4hour shut down. Citing the same Articles Sweden states that fit remains unclear how four hours of exceeding ELV should be detected if only daily average values are indicated in Annex II.

The UK mentioned that the interaction between Article 6 and 13 is not clear.

"In particular, there is a significant problem in defining what "cease feeding waste" might mean, for example in a mass-burn MWI where the feed chute is choke fed. At the point where the ELV is exceeded, there may be many tonnes of waste committed to be fed to the furnace. Does cease feeding mean stop charging the final hopper? Paragraphs 1 and 3 appear to contradict each other, unless paragraph 3 is intended to set a limit on the Member State's discretion allowed under paragraph 1. In any event, these two clauses should be amalgamated. Furthermore paragraph 4 implies that a limit needs to be in place which can never be exceeded; this means that CEMs failure can only lead to abnormal operation if a back-up CEM is used or if it is acceptable to use a surrogate to demonstrate compliance."

2.3.6.5. Annex II

Annex II.1: Belgium found the justification of the higher ELVs for the cement industry unclear and Sweden proposed to use the cement ELVs also for the lime industry.

Sweden proposes to change the Annex II.2.1. ELVs according to the LCP Directive.

Slovenia is in favour of determining ELVs for CO.

Denmark states that the calculation of ELV for co-incineration should be more precise and limit values made more stringent in some cases.

The Netherlands supports the harmonisation of BAT-AELS of the Cement & lime BREF, the WID-ELV and the requirements of the LCP-Directive.

Miscellaneous topics

France proposed to include environmental quality requirements into the WID.

According to the Netherlands WID and IPPC requirements should be coordinated in order to avoid two checks.

Spain wished for more flexibility regarding measurement requirements and wished the elaboration of a technical guide concerning the WID application.

Austria finds it necessary to elaborate an electronic data management and annual on-line reports including harmonised data structures with regard to the requirements of Articles 8, 11 and 13.

2.3.7. Implementation of permit conditions stricter than WID

The Member States have been asked in the questionnaire:

“Have stricter permit conditions according to the IPPC-Directive been imposed? If yes, for how many plants and which parameters? Please provide examples of any such stricter permits conditions”

Replies from 22 MS: Austria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, UK,

Stricter conditions than the WID have been imposed by 9 MS: Austria, France, Ireland, Italy, Netherlands, Slovenia, Spain, Sweden, and UK.

Austria specified that the requirements stem from a stricter implementation of the WID and not of the IPPC.

Ireland, Slovenia, Spain and the UK indicated in total eight plants having stricter ELVs (see table below)

Details on the emission limits values have been indicated by following MS:

Table 5: Reported stricter permit conditions (air)

MS	No of plants	Type of plant	Substance and Air ELV
Austria	No indica-tion	Incineration and co-incineration plants	NOx; HF
France	No indica-tion	Waste incineration plant	NOx 80mg/m³ (Daily average values)
Ireland	3	Cement plant; Power plant; Chemical plant	Daily average values for Power plant: SO_2 191 mg/m³, NOx: 300 mg/m³, Dust 29 mg/m³[9]
Slovenia	1	Incineration plant	Substance/Half hourly average values/Daily average values Total dust/20/5 CO/100/30 HCl/50/8 HF/1/1 NOx/350/180 SO2/150/40 Hg/0,03/0,02 NH3/10/5 PAH/1/-
Sweden	No indica-tion	Incineration plants	NOx – 100 mg/m³ (monthly average value)
UK	3	Incineration plants	NH_3; 2 plants – 10 mg/m³ 1 plant –20 mg/m³
Spain	1		
Germany	2	Precious metal recovery	The permitted ELVs are lower[10] for total dust (10% of ELV), TOC (40% of ELV), NOx (< 10%) and Hg (20% of ELV).

The two German plants are co-incinerating ~340 t of waste per year. All of the substances regulated under Article 11(2) are measured once per year, except for CO which is measured continuously and the missing measurement of TOC measurement of one plant. In general it can be stated that the German implementation of the WID (17. BImSchV) comprises stricter requirements for co-incinerating and incineration plants. The total number of plants falling under the German implementation has not been indicated and cannot be estimated.

France, Slovenia, Sweden and the UK indicated only incineration plants with stricter ELVs than the WID requires. Austria has applied stricter ELVs for incineration and co-incineration plants and Ireland only for co-incineration plants, namely a cement, power and chemical plant.

Sweden specified that the water ELVs have been permitted stricter than in the WID.

[9] Whether the values are stricter than in the WID indicated could not be proven.

[10] if compared to the German WID implementation which comprises stricter requirements.

Table 6: Stricter permit conditions for water in Sweden

Substance	yearly average in mg/l
Total suspended solids	10
Hg	0.01
Cd	0.01
As	0.05
Pb	0.05
Cr	0.05
Cu	0.3
Ni	0.1
Zn	0.6

10 Member States indicated that no stricter requirements exist: Cyprus, Czech Republic, Denmark, Estonia, Finland, Hungary, Latvia, Lithuania, Luxembourg, and Slovakia.

Cyprus indicated that "extra conditions have been imposed referring to the efficient use of energy and the measures taken to prevent accidents".

Finland mentioned that additional conditions refer to noise abatement.

Romania indicated that "conditions that are imposed are according to the IPPC – Directive". But since no details have been provided it could not be verified whether they are stricter than the ones required according to the WID.

2.3.8. Report according to Article 12.2

All Member States have been asked regarding the provision of Article 12 (2) to provide a list of co-incinerations plants (except cement & lime industry) falling under Article 12(2) of the Waste Incineration Directive

Article 12(2): *"For incineration or co-incineration plants with a nominal capacity of two tonnes or more per hour and notwithstanding Article 15(2) of Directive 96/61/EC, an annual report to be provided by the operator to the competent authority on the functioning and monitoring of the plant shall be made available to the public. This report shall, as a minimum requirement, give an account of the running of the process and the emissions into air and water compared with the emission standards in this Directive. A list of incineration or co-incineration plants with a nominal capacity of less than two tonnes per hour shall be drawn up by the competent authority and shall be made available to the public."*

Answers were received from 16 MS: Austria, Bulgaria, Cyprus, Czech Republic Estonia, Finland, Hungary, Ireland, Lithuania, Luxembourg, Netherlands, Slovak Republic, Slovenia, Spain, Sweden, and UK.

Following 14 Member States provided the list comprising in total 112 plants:

Table 7: Number of Article 12(2) plants reported by Member States

Member State	Number of Article 12 (2) plants indicated		
	Co-incineration except cement& lime	Cement plants	Waste incineration
Bulgaria	2		2
Czech Republic		2	3
Estonia	1		
Finland	6		
Hungary	1	4	
Ireland	1		
Lithuania	2	1	
Luxembourg	2		
Netherlands	4		
Romania			7
Slovak Republic		4	14
Slovenia	2	1	2
Spain	3	6	9
UK	33		
Sum	57	18	37

Austria stated that accurate data will be available in the second half of 2007 under following link: http://www.umweltbundesamt.at/umweltschutz/abfall/abfall_datenbank.

Sweden mentioned that those plants comprise approximately 40 plants but did not indicate them.

Luxembourg indicated two large installation plants and their websites:

http://www.environnement.public.lu/air_bruit/inspections_envir/dioxines/resultat_controles/2005_juill_schifflange.pdf

http://www.gouvernement.lu/air_bruit/inspections_envir/dioxines/resultat_controles/2005_novembre_differdange.pdf

As the information provided on the internet of those two plants comprise only information concerning: PAH's; Dust; PM 10, PM2.5; PCCD/F and PCB it is questionable whether they comply with the requirement of Article 12(2).

Information about the Slovenian plants are published at http://www.arso.gov.si/varstvo%20okolja/odpadki/podatki/sezig.pdf

Monthly reports on Article 12(2) incineration plants of the Czech Republic can be found at: http://www.chmi.cz/uoco/emise/spalovny/index.html, see also Annex 2 for details

Poland stated that information on article 12(2) plants is not available on national level.

The detailed list of plants indicated is presented in Annex 2. There are some hints that some plants indicated as Article 12(2) plant have not been mentioned by the Member States when summing up the number of co-incinerating plants per sector (see chapter 2.5.1 and e.g. chemical companies of the UK and Spain in the respective Annex).

2.3.9. Summary of the general Implementation of the WID

The identification of existing plants to be permitted according to the WID was done via registers of installations or checking of existing installation permits or of emission related permits. In some cases the identification of plants has been realised during routine procedures related to licensing. The minority of Member States has provided information requested according to Article 12(2) of the WID on the access to public information about co-incineration and incineration plants which is a reporting requirement without the possibility to be exempted from.

The way the implementation of the WID provisions by the due dates was done was not described in detail but it was mainly stated that operators had to apply for new permits. In some Member States existing permits have been systematically checked. Regional permitting authorities have been informed about new requirements.

Regarding the answers on small waste oil burners the picture varies from “permitting under the WID” to “not allowed” or “not allowed below certain capacities” and “leaving the decision to the consideration of the regulator”. The WID is applied in three Member States for small waste oil burners and in three Member States waste oil burning is prohibited either generally or below certain capacities. In one Member State the WID is applied on a case to case basis.

Regarding the answers on thermal cleaning of equipment or soil the picture again varies from “permitted under the WID”, “consideration of recovery process classification”, “application of other legislation on these installations” up to not permitted under the WID. In three Member States such installations the WID is not applied for such installations. In two Member States the WID is applied and specific ELV have been elaborated. In one Member State the WID seems to be applied on a case to case basis.

Regarding the use of high calorific waste for expansion of the raw material in ceramic kilns the answers vary from “have to fulfil WID requirements” to “application of other legislation like national emission limits or IPPC permits”. In four Member States the WID is applied to ceramic kilns combusting waste and in one only for paper sludges from recycling of paper waste. In two Member States the thermal treatment of waste in this process is not seen as co-incineration as the use of waste is considered as waste treatment step according to the Waste framework Directive or paper sludges are considered to be raw material.

Concerning the question whether emission limit values are valid for the installation or only during the time when waste is incinerated, the answers range from application of the WID even if no waste is incinerated to application of the WID only if waste is incinerated. In one case the application depended on the frequency of waste co-incineration.

Several problems experienced with the WID were reported, mainly referring to definitions and scope, partly to measurement requirements and operating conditions.

Areas of the WID suggested for amendment were the scope, some definitions (incineration plant, co-incineration plant, gasification, pyrolysis, plasma processes, abnormal operating conditions) and clarification or amendments have been required regarding monitoring requirements, operating conditions and Annex II.

Stricter permit conditions according to the IPPC Directive have been imposed for efficient energy use, for noise abatement, accident prevention among others. Stricter emission limit values have been set by some Member States, e.g. for air emissions like total dust, CO, HCl, HF, NO_x, SO_2, Hg but also for waste water emissions.

2.4. Implementation of the WID for waste incineration plants

Whenever the implementing measures are not in line with the requirements of the WID, the respective text is formatted in **bold** and *italic*.

2.4.1. Total number of incineration plants

The associations and selected Member States have been asked to indicate the number of “existing” and “new” plants as defined in the WID. Data about the situation in 21 Member States stemming from several sources[11] were made available. In some cases it was not possible get one value for the number of plants due to equally trustworthy sources. In those cases ranges were indicated. Details on the number of plants reported are shown in the table below.

[11]SYPRED: FR

RenoSam & Ramboll, The most efficient waste management system in Europe - Waste to energy in Denmark, 2006: DK

ISWA: AT, BE, CZ, DK, FI, FR, DE, HU, IT, NL, PT, ES, SE, UK
EURITS: AT, BE, FI, FR, DE, HU, PL, SE, UK. For one Polish and one Austrian plant no detailed information was provided
CEWEP: AT, BE, CZ, DK, DE, FI, FR, HU, IT, LU, NL, PL, PT, ES, SE, UK
Member State Authorities BE, LV, LT, RO, SK, SI, UK
In order to avoid double counting not all sources have been used for above overview.

Table 8: Number of reported incineration plants[12]

	Number of plants			
Country	total (min-max)	existing	new	unknown
Austria	6-9	5		1-4
Belgium	15-18	13		2-5
Czech Republic	35	35		0
Denmark	29-34			29-34
Finland	2	2		0
France	155	111	4	40
Germany	70	62	8	0
Hungary	37	36	1	0
Italy	47-51			47-51
Latvia	6	6		0
Lithuania	1		1	0
Luxembourg	1			1
Netherlands	14	14		0
Poland	2	1		1
Portugal	4	3	1	0
Romania	7-14			7-14
Slovakia	15	11	4	0
Slovenia	2	2		0
Spain	10			10
Sweden	30	27	3	0
UK	78-85	79	6	7
		407	28	
Sum	566-595	435		145-160

In total a maximum of 595 incineration plants were reported for 21 Member States. The majority of incineration plants have been indicated for France (155), followed by the UK (85) and Germany (70). For about 70% of them details on their permitting situation were reported. Among these plants less than 10% have been permitted as new plant according to the WID.

There is at least one clinical waste incinerator under construction in Malta being the successor of an outdated HWI which should have been decommissioned by now [Malta 2003]. Nevertheless, the status of the old and new incinerator could not be clarified. For Malta, Estonia, Greece, Ireland, Bulgaria and Cyprus only

[12] OVAM indicated 15 MWI for the whole of Belgium in 2007: 10 in Flanders, 1 in Brussels and four in Wallonia. Not for all incinerations information about their permitting years was made available. For Belgium and France the number of lines and not plants was indicated by EURITS. The lines are treated as plants. In case of Belgium this was unavoidable since the available three lines in one plant are permitted differently. For the Latvian plants it is not completely clear whether all these plant are existing plants. In case of the UK only some detailed information was made available for all of the 85 incinerators. Most details relate to a pool of plants between 68 and 78 plants.

CEWEP reported zero plants being permitted according to the WID. Information of Vito et al [2007][13] supports this statement for Cyprus, Malta and Greece.

2.4.2. Types of incineration plants

The Associations and selected MS have been asked to differentiate the number of incineration plants according to the following incinerator types: Municipal waste incinerator (MWI), Hazardous waste incinerator (HWI), Clinical waste incinerator (CWI), Sewage sludge incinerator (SSI) and other type of waste incinerators, if available.

Table 9: Number of reported incineration plants per type of incineration

	MWI		HWI		CWI		SSI		Other incinerator	
MS	existing	new	existing	new	existing	new	existing	new	existing	new
Austria	3	0	1	0		0	1		0	0
Belgium	10		3							
Czech Republic	3		22		10					
Finland	1		1							
France	93	3	18	1						
Germany	59	8	3							
Hungary	1		21	1	14					
Latvia			1						5	
Netherlands	11	0	0	0	1	0	2	0	-	-
Poland			1							
Portugal	3	0	0	0	0	0	0	0	0	1
Slovakia	2	1	4		4	2	1			1
Slovenia			2							
Sweden	25	3	1						1	
UK	17	4	15	0	24	0	10	0	7	1
	228	19	93	2	53	2	14	0	13	3
	247		95		55		14		16	
Sums	427									

For all incinerator types the number of existing incinerators is much higher than the number of new incinerators. The largest proportion of plants can be observed for the municipal waste incinerators comprising over 60% of the total. HWI account for ~ 20% and CWI for about 10%. Other waste incinerator types have been indicated by Latvia, Slovakia, the UK, Portugal and Sweden. In Slovakia it is a tallow incinerator and in Latvia incinerators of product samples and animal by-products. The "other" plant types in Sweden, Portugal and the UK have not been specified. 247 MWI and 180 incinerators treating hazardous and other waste have been identified (see Table 9). Taking into account that in total about 595 dedicated incinerators were reported, there are about 168 incinerators lacking assignment as regards the type(s) of incinerated waste.

In addition and partly supporting the information given in Table 9 Vito et al [2007] summarise 344-371 MWI in 13 countries[14], 82 Hazardous waste incin-

[13] VITO and BIO, with Institute for European Environmental Policy and IVM, Data gathering and impact assessment for a possible technical review of the IPPC Directive – Part 2; Fact Sheet C.2.Extension of current IPPC activity definition, 12/09/2007.

erators in 12 MS[15] of which 11 are assigned to Ireland and 43 Sewage Sludge incinerators in six MS[16] of which 23 are assigned to Germany.

Concerning (rendering) plants burning tallow the number of plants falling under the WID is not clear. The only information besides the information from Member States is that in total 223 boilers in 15 EU Member States[17] burn tallow [Ecolas 2007][18] and to maximum 196 of those boilers the WID is applied. The exact number of plants is not reported.

Waste input

The Associations have been asked to indicate the waste input capacities (t/y) of the waste incinerators.

Table 10: Reported annual capacities of waste incineration plants[19]

	Reported capacities (in kt/year)					
MS	Total	MWI	HWI	CWI	SSI	Other
Austria	875	550	100	225		
Belgium	1 262	1 144	118			
Czech Republ	731	646	60	25		
Denmark	3 500					
Finland	205	50	155			
France	16 174	14 600	1 374		200	
Germany	15 648	15 300	348			
Hungary	537	303	131	5		98
Italy	3 100					
Latvia	2		2			
Netherlands	5 822	5 502		8	312	
Poland	20		20			
Portugal	1 122	1 119				3
Slovakia	275	181	86	3	4	1
Slovenia	26		26			
Spain	1 300					
Sweden	3 819	3 487	96			237
UK	5 639	4 246	383	128	617	266
Sum	60 058	47 127	2 899	394	1 133	605
		52 158				

The waste input amounts to 60 million tonnes. Detailed information is missing for around 13% of all reported incinerators. Approximately 90% of all waste is incinerated in MWI. Most waste incineration is carried out in France (~ 27%) and Germany (~ 26%). The average capacity per plant is about 100 000 tonnes/year in above Member States.

[14] AT, BE, DK, FI, FR, DE, IT, LU, PT, ES, SE, NL and the UK.

[15] AT, BE, DK, FI, FR, DE, IE, IT, ES, SE, NL and the UK.

[16] AT, BE, DK, DE, NL and the UK.

[17] AT, BE, DK, FI, FR, DE, HU, IE, IT, LV, NL, SI, ES, SE, UK.

[18] Ecolas NV, Milieu Ltd: Assessment of the application of Community legislation to the burning of rendered animal fat, December 2006, commissioned by the European Commission.

[19] LV, SI, SK = permitted capacities. The Belgian data is not complete. The amount of waste incinerated in the Belgian MWI's stems from a Flemish publication [OVAM 2006].

2.4.3. Granted exemptions from operating conditions (Article 6)

Associations and additional Member States have been asked to indicate whether the permit includes exemptions regarding operation conditions as demanded by Article 6 of the WID.

Answers were received for 11 Member States and for seven Member States a positive answer has been given (see table below):

Table 11: Reported exemptions from operating conditions (Article 6)

	Number of exemptions granted for				
	the gas resulting from the process is raised to a temperature of 850 °C for two seconds	hazardous wastes with >1 % halogenated organic substances: 1100°C for at least two seconds	the use of specific fuels during start-up and shut-down or when the temperature falls below 850 °C or 1 100 °C	Automatic system to prevent waste feed: at start-up, until the temperature > 850 °C or 1 100 °C	Automatic system to prevent waste feed: whenever the temperature < 850 °C or 1 100 °C
Belgium		2			
Finland		3			
France			1		1
Germany	some	at least 3	some	some	67
Slovakia			14	2	2
Sweden	4	1	2	1	1
UK[20]	4	4	1	1	1
Sum	at least 8	at least 13	at least 18	at least 4	72

In total at least 115 exemptions[21] were granted. Most exemptions occurred in Germany even though they could not be quantified for all cases. The exemption most often granted is from the automatic system to prevent waste feed whenever the temperature < 850 °C or 1 100 °C (72), followed by "the use of specific fuels during start-up and shut-down or when the temperature falls below 850 °C or 1 100 °C" with at least 18 exemptions. It is not possible to assess whether these exemptions are in line with the WID as the detailed permit per plant for each of the exemptions would be required for such an assessment.

2.4.4. Implementation of exemptions from the emission measurements with regard to Air

The associations and additional Member States have been asked to indicate the monitored emissions into air. Details about the measurement practice in the Member States can be found in Annex 2.

[20] Eurits and MS data as the information provided differs.

[21] The number of exemptions does not equal the number of plants having exemptions as one plant having several kilns could have also several exemptions.

2.4.4.1. Implementation of exemptions from the emission measurements according to Article 11(6)

Art. 11(6) Periodic measurements as laid down in paragraph 2(c) of HCl, HF and SO_2 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. Art. 2(c) at least two measurements per year […]

HCl

Answers were received from 15 Member States: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, UK.

Changed measurement requirements are granted in seven countries.

In total 97 exemptions from the continuous measurement of HCl were indicated by the Czech Republic, France, Germany, the Netherlands, Slovakia, Slovenia and Sweden.

The number of measurements per year ranges from one to four.

In France and the Czech Republic some plant measure both periodically and continuously, therefore the exemptions indicated by those countries might not be in all cases real exemptions as continuous measurements are carried out as well.

For Sweden and two Slovakian plants the number of measurements was not indicated.

One measurement has been granted in the Czech Republic.

HF

Answers were received for 15 MS: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, UK,

Changes in the measurement requirements are only granted in ten of these countries: Austria, Czech Republic, Finland, France, Germany, the Netherlands, Slovakia, Slovenia, Sweden and the UK

Information about the measurement practice is missing in Hungary for 30 plants, Slovakia for 1 plant, for some[22] plants in the UK, one plant in Finland, 40 in France and in Sweden for six plants. For the remaining plants 337 exemp-

[22] The exact number of plants missing is not known as different information.

tions have been granted, most of them in France (96) and Germany (70). In France some plants measure both periodically and continuously.

The number of measurements ranges from 1 to 24 per year. One plant in Finland measures HF twice a month. For Sweden the number of measurements was not indicated.

One measurement per year has been granted in Slovakia (4 plants) and France (1 plant).

SO_2

Answers were received by 15 MS: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, UK.

In 90 cases exemptions from the continuous measurement requirements are granted in the Czech Republic, France, the Netherlands, Slovakia, UK and Sweden.

Information about the measurement practice is missing in Finland for one plant, in Hungary for 17 plants, in the UK for some plants, in France for 40 plants and in Sweden for 3 plants.

The number of measurements per year ranges from one to four.

For Sweden the number of measurements was not indicated. For the Czech Republic the number of plants with periodical measuring procedure is missing. In France and the Czech Republic some plant measure both periodically and continuously, therefore the exemptions indicated by those countries might not be in all cases real exemptions as continuous measurements are carried out as well.

One measurement per year has been granted in the Czech Republic and in Slovakia.

Conclusion

One measurement per year instead of two as required by Article 11(6) was indicated in three MS (CZ, SK, FR) for all or some of the substances affected by Article 11(6). In two MS (CZ, FR) some plants measure continuously and periodically, therefore the exemptions not covered by the WID might not be in all cases real exemptions as continuous measurements are carried out as well. However, the measurement procedure of Slovakia seems not to be in line with the WID

Table 12: Reported exemptions for the monitoring requirements according to Article 11(6) incineration

Substance	HCl	HF	SO2
Sum MWI	85	228	80
Sum HWI	1	26	0
Sum not spec	11	83	10
Sum	97	337	90

2.4.4.2. Implementation of exemptions from the emission measurements according to Article 11(7)

Art. 11(7) WID:

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.

PCDD/F

Answers were received for 15 MS: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, and UK.

Finland and Germany indicated cases of continuous sampling for PCDD/F[23].

For the plant in Belgium no continuous sampling was indicated although all incinerators in Belgium are measuring PCDD/F continuously.

[23] Germany for almost all plants.

Measurement reductions from two measurements to one per year were only indicated by France (one plant), Lithuania (one plant) and Slovakia (5 plants)

Information about the measurement practice is missing for one plant in Finland, 10 plants in Hungary, nine in Sweden, 40 in France and 83 in the UK.

For Sweden and a part of the Hungarian and German plants the number of measurements was not indicated.

Heavy metals

Answers were received for 15 MS: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, and UK.

Exemptions from two measurements to one per year for the sum of heavy metals and Cd + Tl were indicated by France (one plant), Lithuania (one plant) and Slovakia (4 plants).

73 plants measure mercury continuously: 1 in Finland, 69 in Germany[24], 2 in Portugal and 1 in Sweden. Exemptions from two measurements to one per year were only indicated by France (one plant), Lithuania (one plant), Slovakia (three plants) and the Czech Republic (unspecified number).

Information about the measurement practice is missing for 78-81 plants in France, one plant in Finland, 9 plants in Hungary, nine in Sweden, some plants in Slovakia and in the UK[25].

For some Swedish, Hungarian and German plants the number of measurements was not indicated.

Slovakia has indicated that one to two plants do not have to measure Heavy Metals at all.

[24] This number has been doubted subsequently by CEWEP. It was stated that approximately 35 of the Germany plant are measuring Hg continuously.

[25] According to DEFRA no derogations have been granted from Article 11(7) for the monitoring of the sum of Heavy Metals.

Conclusion

Apparently in none of the reported plants the measurement reduction of heavy metals from twice a year to one every two years has been applied.

Some Slovakian plants do not have to measure the substances affected by Article 11(7). According to the authorities the lack of measurement is justified as those plants "demonstrated by technical calculation and results of chemical analysis, that their waste does not contain heavy metal more than 10% emission limit value. According to the WID, at least one measurement per year or every two years has to be carried out for these substances. Therefore the missing measurements are not in line with the WID.

Substance	Hg	Cd + Tl	Sum of HM	PCCD/F
Sum MWI	1	1	1	1
Sum HWI	0	0	0	0
Sum not spec	6	3	6	6
Sum	7	4	7	7

Table 13: Reported exemptions for the monitoring requirements according to Article 11(7) incineration

2.4.4.3. Implementation of the emission measurement requirements according to Article 11(2)a

Information about the requirements for NO_x, CO, Total dust and TOC to be measured continuously according to Article 11 (2)a has been indicated for 15 MS[26]: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden and the UK.

All of these substances are measured continuously ***except in two plants in France and one in Poland which are measuring NOx periodically either twice (PL) or four times a year (FR). This measurement practice is not in line with the WID.*** For details see annex 2.

In France, the Czech Republic and Sweden periodical measurement for some plants and substances are carried out in addition to the continuous measurement.

[26] not for all MS the measurement practices for all four substances have been indicated.

2.4.4.4. Application of Article 7(5)

The associations and selected Member States have been asked to indicate the number of plants measuring PAHs and being subject to ELV for PAH or other pollutants.

In following Member States PAHs are monitored:

Table 14: Reported monitoring of PAH

MS	Total number of plants	Number of plants with periodical measurement	Total number of measurements/per year
Austria	4	1	1
France	115	2	4
Germany	70	67	
		3	3[27]
Sweden	30	2	
UK	85	76	2

The German plants are all measuring Benzo(a)pyrene plus As, Cd, Co, Cr according to the national implementation of the WID (17.BImSchV) periodically. The ELV for this combination of pollutants is 0.05 mg/m³.

Other substances

A number of other substances are measured by different Member States (see table below).

[27] Only for the three hazardous incinerators the number of measurements has been reported

Table 15: Reported monitoring of other substances[28]

MS	Pollutant	Number of plants with continuous measurement	Number of plants with periodical measurement	Number of measure-ments/year
France	CFC		1	1
Germany	CFC		1	1
Czech Republic	CO_2			
Portugal	CO_2	2		
France	HCFC		1	1
Germany	HCFC		1	1
France	N_2O		1	1
Germany	N_2O		1	1
Czech Republic	NH_3			
France	NH_3	2		
Germany	NH_3	2		
Netherlands	NH_3	6		
Portugal	NH_3	3		
France	SF_6		1	1
Germany	SF_6		1	1
Germany	unspecified		1	3
Sweden	unspecified	15	6	

2.4.5. Level of compliance with the emission measurements for waste water according to Article 11(14)

The associations and additional Member States have been asked to indicate which emissions of waste water from wet flue gas treatment are monitored. The reported number of plants having waste water discharges was 125 in following 11 countries: Austria, Belgium, Czech Republic, France, Germany, Hungary, Netherlands, Slovakia, Slovenia, Sweden, UK.

Article 11 (14)b: TSS

Answers were received for 9 MS: Austria, Belgium, Czech Republic, France, Germany, Hungary, Netherlands, Sweden, UK.

Belgium, France and Sweden measure TSS continuously either partly (SE, FR) or exclusively (BE).

The number of non-continuous measurement varies from four to 365 times per year.

Hungary, France, the UK and Austria measure 365 times a year which is in compliance with Art 11 (14)b „*The following measurements shall be carried out at the point of waste water discharge: […]*

[28] No information on flow rates are available

(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;"

The Netherlands, Czech Republic and Germany measure less than 365 days per year. In the Czech Republic it was indicated however that depending on the plant also daily measurements are carried out (twice a day).

A number of plants in France do not measure TSS. According to the respective association the emission limit values for waste water apply for all the industrial waste water discharges in the French decree transposing the WID, and not only for waste water from wet flue gas treatment (as it is the case in the WID). But since this does not explain why some plants are not measuring TSS it is considered that ***this practice is not in line with the WID.***

In Sweden it is not clear whether one plant is not measuring since the number of plants with wet FGT is not clear. For the spot measurement Sweden did not indicate the number measurements.

Details about the measurement practice in all Member States can be found in Annex 2.

Article 11(14)c: Heavy metals

Article 11.14(c) of the WID requires that *"The following measurements shall be carried out at the point of waste water discharge: […]*

(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;"

Answers to the question related to this paragraph were received for 11 MS: Austria, Belgium, Czech Republic, France, Germany, Germany, Hungary, Netherlands, Slovakia, Slovenia, Sweden, UK,

The heavy metals are measured continuously by plants in Sweden (13) and Hungary (one). For the periodic measurement Sweden did not indicate the number of measurements. The number of measurements ranges from 2 (Slovakia) to 52 (France).

Austria, the Czech Republic, Germany and Slovakia granted exemptions from the measurement requirements of Article 11(14)c. The Czech Republic indicated that depending on the plant also daily measurements are carried out (twice a day).

Details about the measurement practice in all Member States can be found in Annex 2.

Article 11(14) d: PCDD/F

Article 11(14)d of the WID requires that *"The following measurements shall be carried out at the point of waste water discharge: […]*

(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."

Answers to the related question in the questionnaire were received for 11 MS: Austria, Belgium, Czech Republic, France, Germany, Hungary, Netherlands, Slovakia, Slovenia, Sweden, UK.

The number of measurement varies from once (CZ) to 12 times (CZ, BE) per year.

An unspecified number of plants in the Czech Republic granted exemptions from the measurement requirements of Article 11(14) c. Furthermore 25 plants in the Czech Republic do not measure PCDD/F at all.

In Sweden it is not clear whether one plant is not measuring since the number of plants with wet FGT is not clear.

Sweden only indicated the number of plants measuring periodically but did not mention the number of measurements per year.

Details about the measurement practice in all Member States can be found in Annex 2.

Conclusion

A number of plants in France do not measure TSS and this practice is not in line with the WID. Three MS (BE, FR, SE) indicated continuous measurement of TSS.

At least in four MS (AT, DE, CZ, SK) the heavy metals are measured less than monthly. In two MS (SE, HU) they are measured continuously.

An unspecified number of plants in the Czech Republic granted exemptions from the measurement requirements of Article 11(14) c. Furthermore 25 plants in the Czech Republic do not measure PCDD/F at all.

A number of countries measures some or all substances far more than required (BE, FR, SE, HU) and some ***are measuring less than required by Article 11(14) of the WID (AT, NL, CZ, DE, FR, SK). In case of the latter this procedure is not in line with the WID.***

2.4.6. Application of Article 8(8) regarding ELVs for PAHs to water

The associations and additional Member States have been asked to indicate the number of plants comprising ELV for water discharges from the cleaning of exhaust gases for PAHs or other substances and the monitoring of PAHs.

PAHs

Five Member states indicated periodical monitoring of PAHs for 90 plants (see following table).

Table 16: Monitoring of PAHs for water discharges from the cleaning of exhaust gases

MS	Number of plants with periodic measurements	Number of measurements
Hungary	5	2
Netherlands	6	2
France	2	52
UK	76	2
Slovenia	1	52

Details on ELVs were not delivered.

Other pollutants

A number of other pollutants are measured in the following seven Member States (see table below):

Table 17: Reported monitoring of other parameters for water discharges from the cleaning of exhaust gases

MS	Parameter	Number of plants with continuous measurements	Number of plants with periodic measurements	Number of measure-ments
Czech Republic	Al, AOX, DOC, F, Na, NH_4, pH, SO_x		3	
Sweden	unspecified	6	2	
Germany	unspecified		1	12
Slovenia	Total N, N in Ammonia, Total CN, F, Cl, total P, SO4, Sulphate, Sulphite, Sulphides, BOD, COD, AOX		1	4
Czech Republic	Cl	35		3
Slovakia	Non-polar extractable Sulphides			
France	TOC, COD, F, CN, Hydrocarbon, AOX			

Details on ELVs were not delivered.

2.4.7. Exemptions from the emission limit values in Annex V

Answers received for 15 MS: Hungary, Czech Republic, Netherlands, Lithuania, Portugal, Austria, Belgium, Finland, Poland, Slovak Republic, Slovenia, France, Germany, Sweden and UK. Four Member States indicated 43 exemptions (see following table).

Table 18: Reported exemptions from the emission limit values in Annex V

	Daily average values			Half hourly values		CO	
	Total dust **10 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**	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			
				(100 %) A	**400 mg/m3**	daily average	**50 mg/m3**
				(97 %) B	**200 mg/m3**	95% of all 10min averages or	**150 mg/m3**
						95% of all 1/2hourly values per 24h period	**100 mg/m3**
France	1	13	4	-	13	-	2[29]
Germany	-	-	-	-	At least 3[30]	-	At least 3[31]
Sweden						1	1
UK		2					

[CEWEP, EURITS]

It is not possible to assess whether these exemptions are in line with the WID as the detailed permit per plant for each of the exemptions would be required for such an assessment.

2.4.8. Water related - BAT-AELs

The associations and additional Member States have been asked to indicate the number of plants having realised BAT associated operational emission levels for discharges of waste water from effluent treatment plant receiving FGT scrubber effluent.

Information was received for 10 Member States: Czech Republic, Netherlands, Austria, Belgium, France, Germany, UK, Slovakia, Hungary, Poland,

[29] These two plants are equipped with fluid bed furnaces.

[30] For the German plant reference was made to the national WID implementation (17 BImschV).

[31] see footnote 29.

Hungary and Poland indicated that none of their plants is discharging waste water from FGT[32]. Therefore for eight MS information was provided (see following table).

Table 19: Reported number of plants having realised BAT associated emission levels for discharges of waste water from effluent treatment plant receiving FGT effluent

MS		CZ	NL	AT[33]	BE	FR	DE	UK	SK	Sum
Reported total number of plants		35	14	6	3	19	≥3	85	15	96
Reported no of plants with waste water from FGT[34]		35	6[35]	min. 3	3	8	2	18	2	61
Parameter	BAT range in mg/l (unless stated)	Number of plants having realised the BAT associated operational emission levels for discharges of waste water from effluent treatment plant receiving FGT scrubber effluent								
TSS	10 – 30 (95 %)	2	6	3	3	8	1	2	2	27
	10 – 45 (100 %)	0	6		3	0	1	2	2	14
COD	50 – 250	1	6		3	8	0	2	2	22
pH	pH 6.5 – pH 11	2	6	3	3	8	2	2	2	28
Hg	0.001 – 0.03	1	6	3	3	8	1	2	2	26
Cd	0.01 – 0.05	1	6	3	3	8	1	2	2	26
Tl	0.01 – 0.05	0	6	3	3	8	1	2	2	25
As	0.01 – 0.15	1	6	3	3	8	2	2	2	27
Pb	0.01 – 0.1	2	6	3	3	8	1	2	2	27
Cr	0.01 – 0.5	2	6	3	3	8	2	2	2	28
Cu	0.01 – 0.5	2	6	3	3	8	2	2	2	28
Ni	0.01 – 0.5	1	6	3	3	8	1	2	2	26
Zn	0.01 – 1.0	1	6	3	3	8	1	2	2	26
Sb	0.005 – 0.85	0	6	3	3	8	1	2	2	25
Co	0.005 – 0.05	0	6		3	8	1	2	2	22
Mn	0.02 – 0.2	0	6		3	8	1	2	2	22
V	0.03 – 0.5	0	6	3	3	8	1	2	2	25
Sn	0.02 – 0.5	0	6	3	3	8	1	2	2	25
PCDD/F (TEQ)	0.01 – 0.1 ng /l	1	6		3	8	1	2	2	23

In general all BAT-AELs are applied to a similar extent. Only for total suspended solids a significant lower number can be observed. This is due to the fact that in France those values have not been realised.

In some plants of the Czech Republic operational emissions are set by contract with sewage works and the indicated number of plants using BAT-AELS has to be considered as the minimum.

32 For the one Polish plant missing detailed information no statement can be made.

33 According to the Austrian Association "the cited emission levels" for CO, Mn and PCDD/F "are normally met, yet the legal situation in Austria does not enforce values of this low level.

34 Only those plant having waste water from FGT can apply those water related BAT-AELs.

35 agreed estimate with the Dutch Association of Waste Treatment Plants [Vereniging Afvalbedrijven 2007].

One German plant is an indirect discharger with other discharge conditions, because the waste waters are treated in their own chemical-physical treatment plant, where also other waste waters are treated. All own measurements are executed regarding these special conditions of the local authority.

The French Member of CEWEP mentioned very generally that the “96 plants are in compliance with the IPPC Directive” without giving more details. It remains unclear whether the BAT AEL are met or whether the general concept of BAT is fulfilled.

2.4.9. Air related BAT-AELs

The associations and additional Member States have been asked to indicate the number of plants having realised BAT associated emission levels for air emissions.

Answers were received for 10 MS: Germany, Czech Republic, Hungary, Netherlands, Austria, Belgium, Poland, Sweden, UK and Slovakia.

Table 20: Plants having realised BAT associated operational emission levels for air

		Substance(s)	HCl	HF	SO_2	NO and NO_2 as NO_2 for installations using SCR	NO and NO_2 as NO_2 for installations not using SCR	Gaseous and vaporous org. substances, as TOC	CO	Hg	Cd and Tl	other metals	Dioxins and furans (ng TEQ/Nm³)	Ammonia (NH_3)
		Non-continuous samples								<0.05	0.005 - 0.05	0.005 - 0.5	0.01 – 0.1	<10
		½ hour average	1 – 50	<2	1 – 150	40 – 300	30 – 350	1 – 20	5 – 100	0.001 – 0.03				1 – 10
Country	Total Number of plants	24 hour average	1 – 8	<1	1 – 40	40 – 100	120 – 180	1 – 10	5 – 30	0.001 - 0.02				<10
Czech Republic[36]	35		All plants	All plants	All plants	not available	All plants	All plants	All plants	All plants	All plants	All plants	All plants	All plants
Hungary	37		7	7	7	0	2	7	7	7	6	6	6	1
Finland[37]	2		2	2	2		2	2	2	2	2	2	2	
Netherlands	14		14	14	14	14	14	14	14	14	14	14	14	14
Austria	6		4	4	4	4	4	4	4	4	4	4	4	4
Belgium	3		3	3	3	3	3	3	3	3	3	3	3	3
Poland	2		1	1	1	0	0	1	1	1	1	1	1	0
Portugal	4		4	4	4	not available	4	4	4	4	4	4	4	4
Sweden	2		1	1	1	0	1	1	1	1	1	1	1	1
UK	2		2	2	2	0	0	2	2	2	2	2	2	
France[38]	115		19	4	19	0	17	19	19	19[39]	19	19	19	0
Slovakia	15[40]		3	4	3	4	3	4	4	4	4	4	4	
Germany[41]	70		3	3	3	3		3	3	3	3	3	3	3

For Austria, Germany, Belgium, the UK, France and Slovakia the number of plants achieving BAT-AELs is not complete

36 Referring to HF: < 1 non-continuous sample, Hg < 0,05, NH3 < 10 non-continuous samples.

37 Two lines from one plant indicated and the data is only referring to "monitoring of ½ hour average and 24 hour average comparing with permitted emission limits (equal of WID). 1 year averages for both FGT- lines are available".

38 Only Eurits data.

39 All plants compared to Hg < 0,05.

40 Only referring to the four plants having a nominal capacity of > 2 tonnes waste/h.

41 Only data from EURITS. EURITS specified that all German plants "can meet BAT AELs on a monthly basis or in shorter time frames, but for plant operation the WID ELVs are used".

The number of plants achieving BAT-AELs is similar for the different substances. Only regarding BAT-AELs for the parameters NH_3, HF and “NO_2 for installations using SCR” lower values can be observed. This mainly results from the low number of realised BAT-AELs in France.

EURITS replied for France “the limit values are those fixed in the WID, ie HCl 1-60 (1/2 hour) and 1-10 (24 hour); SO_2 1-200 (1/2 hour) and 1-50 (24 hour); NOx 30-400 (1/2 hour) and 120-200 (24 hour); CO 5-50 (24 hour)”. The French Member of CEWEP mentioned very generally that the “96 plants are in compliance with the IPPC Directive” without giving more details. It remains unclear whether the BAT AELs are met or whether the general concept of BAT is fulfilled.

In CZ “the emission levels for incinerators are provided by law. No stricter values for municipal waste incinerators are insisted”. Apparently this means that the BAT-AELs have been incorporated into the Czech law and therefore have to be followed accordingly.

The Dutch plants only report the emission limit values but not the technique with which they achieve the values.

2.4.10. Realised BAT-Techniques

The associations and additional Member States have been asked to indicate the number of plants having realised selected BAT-techniques (see below)

Table 21: Selected BAT-Techniques for waste incinerators

Technique			No.
The use of auxiliary burner(s) for start-up and shut-down and for maintaining the required operational combustion temperatures (according to the waste concerned) at all times when unburned waste is in the combustion chamber,			1
The use of primary (combustion related) NO_x reduction measures to reduce NO_x production, together with either SCR or SNCR			2
For the reduction of overall PCDD/F emissions to all environmental media, the use of:	The use of installation designs and operational controls that avoid those conditions that may give rise to PCDD/F reformation or generation, in particular to avoid the abatement of dust in the temperature range of 250 – 400 C		3
	The use of a suitable combination of one or more of the following additional PCDD/F abatement measures	Adsorption by the injection of activated carbon or other reagents with bag filtration, or	4
		Adsorption using fixed beds, or	5
		Multi layer SCR, adequately sized to provide for PCDD/F control, or	6
		The use of catalytic bag filters,	7
If re-burn of FGT residues is applied, then suitable measures should be taken to avoid the re-circulation and accumulation of Hg in the installation			8
For the control of Hg emissions where wet scrubbers are applied as the only or main effective means of total Hg emission control:	The use of a low pH first stage with the addition of specific reagents for ionic Hg removal, in combination with the following additional measures for the abatement of metallic (elemental) Hg	Activated carbon injection, or	9
		Activated carbon or coke filters.	10
For the control of Hg emissions where semi-wet and dry FGT systems are applied, the use of activated carbon or other effective adsorptive reagents for the adsorption of PCDD/F and Hg, with the reagent dose rate con-trolled			11
Where wet flue-gas treatment is used:	The use of on-site physico/chemical treatment of the scrubber effluents prior to their discharge from the site,		12
	The separate treatment of the acid and alkaline waste water streams arising from the scrubber stages, when there are particular drivers for the additional reduction of releases to water that result, and/or where HCl and/or gypsum recovery is to be carried out		13
	The re-circulation of wet scrubber effluent within the scrubber system, and the use of the electrical conductivity of the re-circulated water as a control measure, so as to reduce scrubber water consumption by replacing scrubber feed-water,		14
	The use of sulphides (e.g. M-trimercaptotriazine) or other Hg binders to reduce Hg (and other heavy metals) in the final effluent,		15
	When SNCR is used with wet scrubbing the ammonia levels in the effluent discharge may be reduced using ammonia stripping, and the recovered ammonia re-circulated for use as a NO_X reduction reagent		16
The use of a suitable combination of the techniques and principles for improving waste burnout to the extent that is required so as to achieve a TOC value in the ash residues of below 3 wt % and typically between 1 and 2 wt %			17

Answers were received for 13 MS: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Poland, Portugal, Slovenia, Slovakia, Sweden and UK.

For Finland answers were only delivered for the HWI (EURITS). The German member of CEWEP indicated that all installations have realised all techniques while the CEWEP member of France[42] stated that 96 plants are in compliance with the IPPC directive. These statements could not be incorporated into the analysis below as some of the techniques cancel each other out and the specific number of plants was not indicated for the French and German plants. Detailed data concerning this chapter is presented in Annex 2

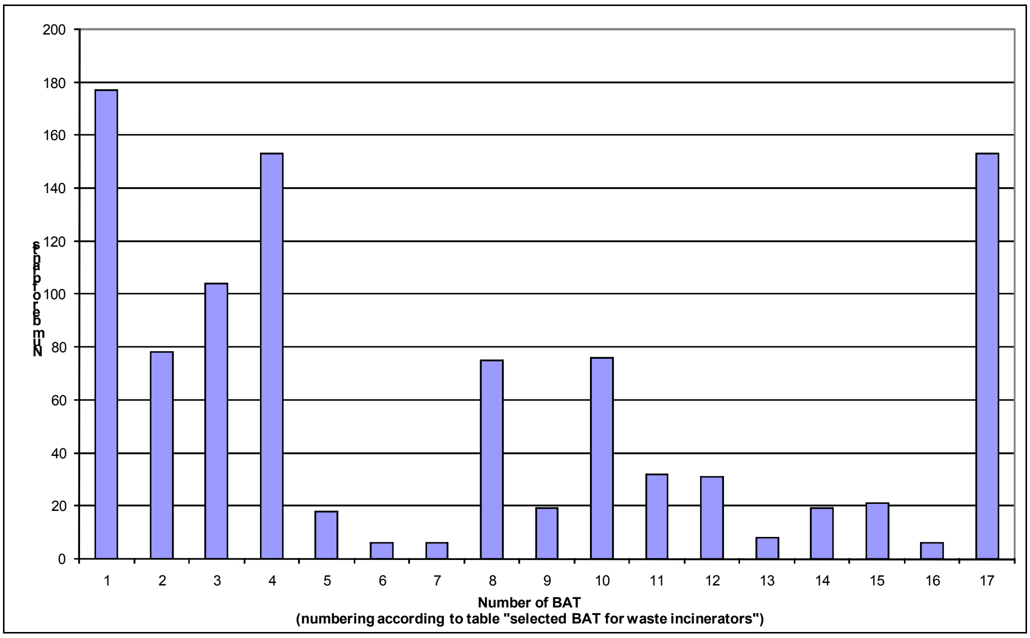

Figure 1: Realised BAT (see Table 21) reported by Associations

[42] see also comment below.

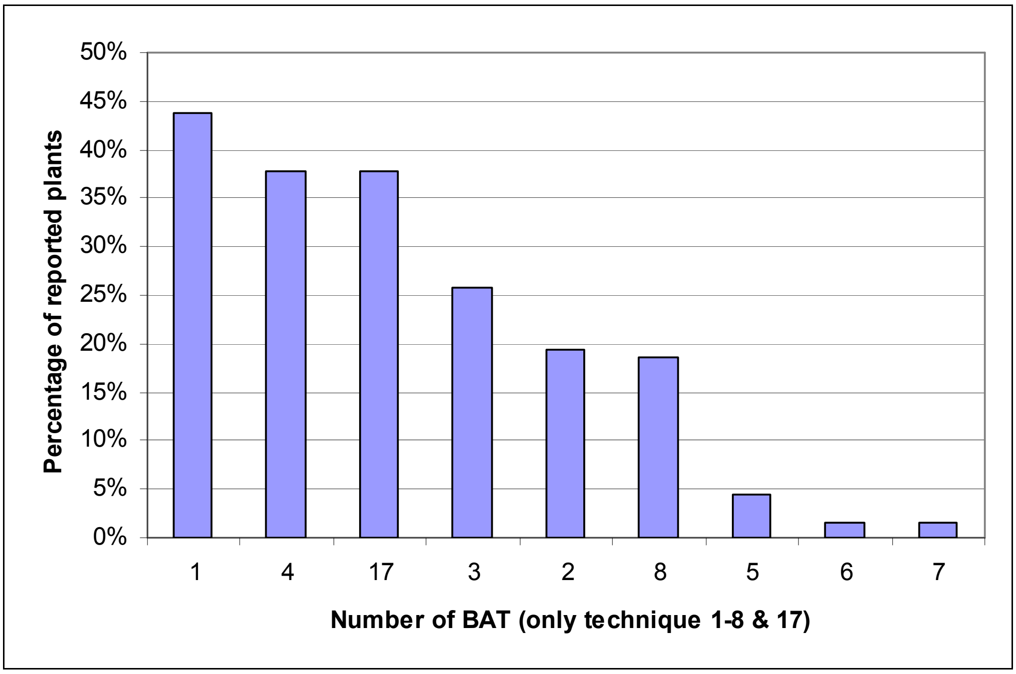

Figure 2: Percentage of realised BAT no. 1-8, 17[43]

The answers and the degree of completion with regard to the total number of plants differ largely from Member State to Member State. It has to be remarked that the number of the techniques 9 to 16 depends on the basic setting of the plant (using wet, semi dry or dry FGT) while the other techniques can theoretically be used for all indicated plants.

About 40% of the plants in the respective Member States have following techniques available (see Table 21, Figure 2 and Figure 3):

- PCDD/F abatement measures - adsorption by the injection of activated carbon or other reagents with bag filtration (no.4),
- The use of auxiliary burner(s) for start-up and shut-down and for maintaining the required operational combustion temperatures (according to the waste concerned) at all times when unburned waste is in the combustion chamber (no 1),
- The use of a suitable combination of the techniques and principles for improving waste burnout to the extent that is required so as to achieve a TOC value in the ash residues of below 3 wt % and typically between 1 and 2 wt % (no. 17).

The latter two techniques are required by Article 6(1) of the WID. The fact that not all plants are equipped with those techniques indicates that the Member States laid down conditions different from those of Article 6(1). These derogations are possible according to Article 6(4) of the WID.

[43] It has to be remarked that the number of the techniques 9 to 16 depends on the basic setting of the plant (using wet, semi dry or dry FGT) while the other techniques can theoretically be used for all indicated plants. Therefore the graphical evaluation was split into two graphs (Figure 2 and Figure 3).

About 20-25% of the respective plants have realised following techniques

- The use of installation designs and operational controls that avoid those conditions that may give rise to PCDD/F reformation or generation, in particular to avoid the abatement of dust in the temperature range of 250 – 400 C (no. 3),
- The use of primary (combustion related) NO_X reduction measures to reduce NO_X production, together with either SCR or SNCR (no. 2),
- If re-burn of FGT residues is applied, suitable measures to avoid the re-circulation and accumulation of Hg in the installation (no. 8).

Below 5% of the plant used other PCDD/F abatement techniques as the one mentioned above (no. 5 – 7).

For the BAT depending on the basic setting of the plant (BAT no. 9-16) only estimates can be given as the number of plant having wet FGTs or scrubbers is not exactly known.

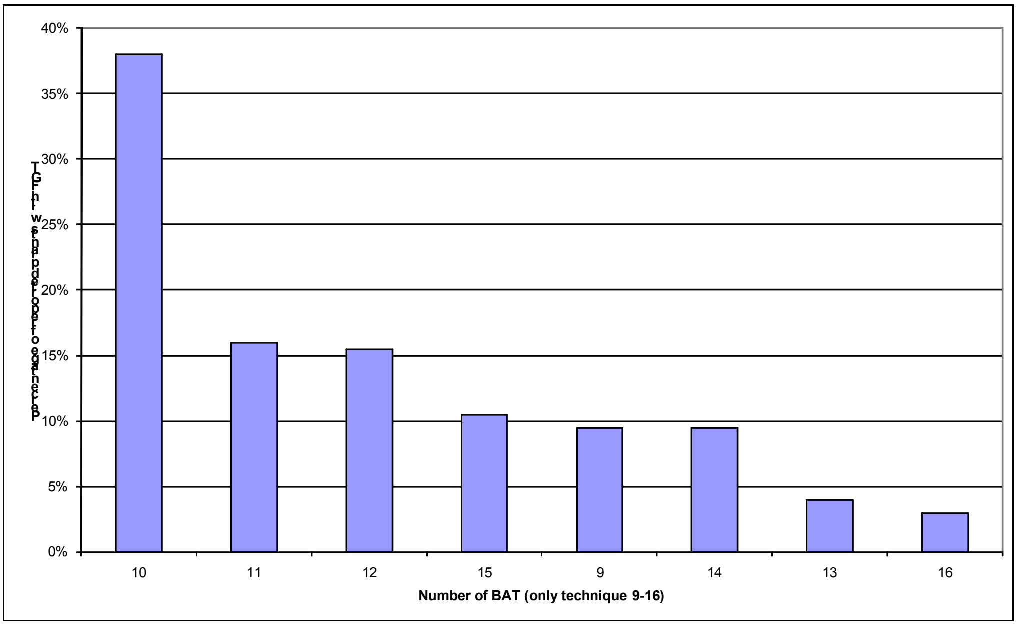

Figure 3: Percentage of realised BAT no. 9-16

Activated carbon or coke filter for the control of Hg emissions are most prominent within these BAT. The lowest degree of implementation is found for:

- The separate treatment of the acid and alkaline waste water streams arising from the scrubber stages, when there are particular drivers for the additional reduction of releases to water that result, and/or where HCl and/or gypsum recovery is to be carried out (no. 13) and
- When SNCR is used with wet scrubbing the ammonia levels in the effluent discharge may be reduced using ammonia stripping, and the recovered ammonia re-circulated for use as a NOX reduction reagent (no. 16).

2.4.11. Summary of the implementation of the WID in dedicated incineration plants

Text passages in italics mark practices which are seen as being not in line with the requirements of the WID

Number of plants and waste amounts

In total 596 incineration plants were identified for 21 Member States. The highest number of incineration plants have been indicated for France (155), followed by the UK (85) and Germany (70). For about 70% of the plants, details on their permitting situation were reported. Among these plants less than 10% have been permitted as being "new" according to the WID and this is true for all different types of plants.

Over 60% of the incineration plants are municipal waste incinerators (MWI). Hazardous waste incinerators (HWI) account for ~ 20% and clinical waste incinerators (CWI) for about 10%.

The total reported waste input amounts to 60 million tonnes. Detailed information is missing for around 13% of all reported incinerators. Approximately 90% of all waste is incinerated in MWI. Most waste incineration is carried out in France (~ 27%) and Germany (~ 26%). The average capacity per plant is about 100 000 tonnes/year in above Member States.

Exemptions from operating conditions

Exemptions from the operating conditions of Article 6 for the flue gas temperature and residence time have been authorised in at least 7 Member States and at least 115 plants. Most exemptions occurred in Germany even though they could not be quantified for all cases. Due to this, the exemption most often granted is from the automatic system to prevent waste feed whenever the temperature < 850 °C or 1 100 °C (72), followed by "the use of specific fuels during start-up and shut-down or when the temperature falls below 850 °C or 1 100 °C" with at least 18 exemptions. It was not possible to assess whether these exemptions are in line with the WID as the detailed permit per plant for each of the exemptions would be required for such an assessment.

Exemptions from monitoring requirements

Table 22: Reported exemptions for the monitoring requirements according to Article 11(6) and 11(7) incineration

Substance	HCl	HF	SO_2	Hg	Cd + Tl	Sum of HM	PCCD/F
Sum MWI	85	228	80	1	1	1	1
Sum HWI	1	26	0	0	0	0	0
Sum incinerators (not specified)	11	83	10	6	3	6	6
Sum	97	337	90	7	4	7	7

For details on this topic please see chapter 2.4.4 and Annex 2

One measurement per year instead of two as required by **Article 11(6)** was indicated in three MS (CZ, SK, FR) for all or some of the substances affected by Article 11(6). In two MS (CZ, FR) some plants measure continuously and periodically, therefore the exemptions not covered by the WID might not be in all cases real exemptions as continuous measurements are carried out as well. *However, the measurement requirements in Slovakia seem not to be in line with the WID*

Apparently in none of the reported plants the measurement reduction of heavy metals from twice a year to one every two years as laid down in **Article 11(7)** has been applied. All measurement reductions are based on an annual and not biennial basis meaning that the use of the exemption possibility has only been partially used to its full extent. *Two Slovakian plants do not have to measure all or some of the substances affected by Article 11(7) due to the proven fact that the incinerated waste contains only a very low proportion of heavy metals. This is not in line with the WID.*

*Some plants in France and Poland are measuring NOx periodically. This is not in line with **Article 11(2)**a of the WID.*

Additional ELVs or monitoring requirements

The possibility according to **Article 7(5)** to measure PAH's (air) have realised at least 151 plants in 5 MS. Eight other air related pollutants are measured at least in 48 plants in 6 MS.

In a number of countries (BE, FR, SE, HU) some or all substances are measured more often than required by **Article 11(14)** regarding waste water from the cleaning of exhaust gases and some plants *are measuring less than required by Article 11(14) of the WID (AT, NL, CZ, DE, FR, SK). In case of the latter this is not in line with the WID.*

The possibility to measure PAH's (water) according to **Article 8(8)** has been realised at least by 90 plants in 5 MS (HU, NL, FR, UK, SI).At least 6 MS measure other water related pollutants like AOX or Ammonia.

Exemptions concerning ELVs

At least 43 plants in four MS (FR, DE, SE, UK) have been granted exemptions for ELVs in **Annex V**. It is not possible to assess whether these exemptions are in line with the WID as the detailed permit per plant for each of the exemptions would be required for such an assessment

Application of BAT and achievement of BAT-AELs

In general all **BAT-AELs** (water) are achieved to a similar extent based on the information provided by associations and Member States authorities. Only for total suspended solids a significant lower number can be observed. This is due to the fact that in France those values have not been realised.

The number of plants achieving BAT-AELs (air) is similar for the different substances. Only for the BAT-AELs for the parameters NH_3, HF and “NO_2 for installations using SCR” lower values can be observed. This mainly results from the low number of realised BAT-AELs in France.

According to the information received, following **BAT** are applied most often:

- PCDD/F abatement measures - adsorption by the injection of activated carbon or other reagents with bag filtration,
- The use of auxiliary burner(s) for start-up and shut-down and for maintaining the required operational combustion temperatures (according to the waste concerned) at all times when unburned waste is in the combustion chamber,
- The use of a suitable combination of the techniques and principles for improving waste burnout to the extent that is required so as to achieve a TOC value in the ash residues of below 3 wt % and typically between 1 and 2 wt %.

The latter two techniques are required by Article 6(1) of the WID. The fact that not all plants are equipped with those techniques indicates that the Member States laid down conditions different from those of Article 6(1). These derogations are possible according to Article 6(4) of the WID.

2.5. Implementation of the WID for co-incineration plants

This chapter summarises the outcome from the data collection comprising information of the Member States and associations (for details see 2.2.2). Chapter 2.5.1 and 2.5.2 describe the implementation of the WID in the cement and lime industry including inter alia the exemptions from monitoring requirement and ELVs. Chapter 2.5.3 describes the information received from the Member States regarding all other sectors co-incinerating waste. This information has been aligned with the data from associations including the cement and lime industry in Chapter 2.5.4. Chapter 2.5.5 to 2.5.15 present the information about the implementation of the WID for various industries co-incinerating waste with the exemption of the cement and lime industry.

2.5.1. Cement industry

All information provided in the sections below stems from the data submission of CEMBUREAU based on the permitting situation of their plants in 2005 and additional voluntary or requested information of certain Member States authorities.

In total 162 plants have been indicated by CEMBUREAU to fall under the WID covering 22 MS[44] and Norway. About 90% of those plants can be considered as "existing plants" according to Article 3(6) of the WID

Regarding possible exemptions from the requirements of the WID following data restrictions occurred:

- CEMBUREAU indicated only the total number of plants measuring emissions continuously and periodically and the minimum and maximum number of measurements per year.
- Figures per Member States have not been made available[45].
- For some substances the number of plants indicated exceeds the total number of plants identified. According to CEMBUREAU this is due to the fact that in a number of plants periodic and continuous measurements are carried out.

[44] Austria ,Belgium, Czech Republic, Denmark, Estonia , Finland, France, Germany, Greece ,Hungary , Ireland, Italy, Latvia, Luxembourg, Netherlands, Poland ,Portugal ,Romania ,Slovenia , Spain, Sweden, UK.

[45] except for some MS and waste amounts.

2.5.1.1. Waste amounts used for co-incineration in cement kilns

The total amount of waste co-incinerated in 2004 was 6.2 million tonnes[46], 83% of it being non-hazardous waste,

Limited data have been made available regarding the amounts per Member State. Table 23 gives an overview of data provided by Member States and CEMBUREAU (partly aggregated data because of data protection reasons).

Table 23: Waste amounts used for co-incineration in cement kilns

Member States	Amount of waste used (averages per plant and country or group of countries) (kt/y)[1]	Number of cement plants in the country or group of countries[2]	Total amount of used waste (kt/y)[3]
Austria	30	9	270
Belgium, Netherlands, Luxembourg	139	7	973
Czech Republic	40	2-6	80-240
Denmark, Finland, Sweden, Ireland	75	4-10	300-750
Estonia, Latvia, Poland, Hungary	27	18	491
France	37	27-33	1 009-1 233
Germany	57	33-38	1 876-2 161
Greece, Portugal, Romania, Slovenia	9	22-23	202-212
Italy	13	58	760
Spain	16	37	574
United Kingdom	24	15-21	361-506
Sum		**238-254**	**7 040-8 023**

Sources: [1] [CEMBUREAU 2007], [2] [CEMBUREAU 2006-3] and Member States information, [3] own calculation

The calculation of waste amounts per Member States as performed in Table 23 shows some deviation to the total waste amount as indicated by CEMBUREAU (+ 14% to 29%). Nevertheless it can be concluded that the highest amounts of wastes are <u>used</u> in Germany and France.

Substitution rates

The average national substitution rates[47] for hazardous waste range from 0.7% for hazardous and 2% for non-hazardous waste in EL + PT + RO + SI to 15 % in the Czech Republic and DK + FI + SE + NO + IE for hazardous waste and 43.6% in Germany for non-hazardous waste. Only in Austria and France in some plants more than 40% of resulting heat release stems from hazardous waste.

46 [CEMBURAU 2004] CEMENT & LIME BREF REVISION, CEMBUREAU CONTRIBUTION; 2003 and 2004 statistics on the Use of Alternative Fuels & Materials in the clinker production in the European cement industry,

47 The substitution rate describes the substitution of fossil fuels by waste and is expressed in % of the total heat release of the process..

Waste types used for co-incineration

CEMBUREAU indicated the tonnes of wastes used within their industry clustered according to their type.

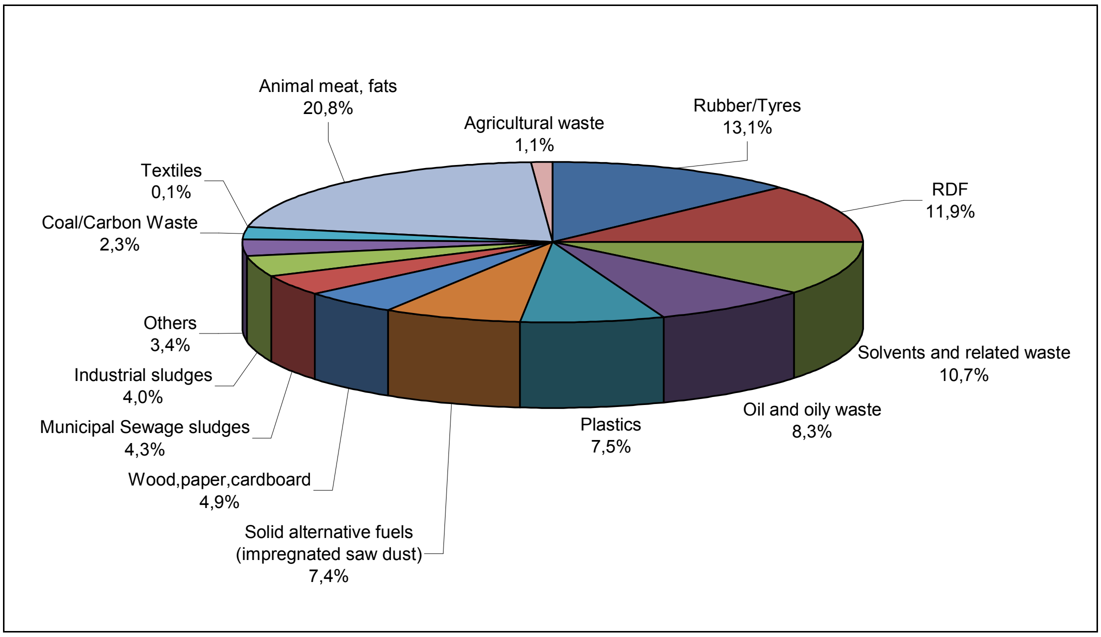

Figure 4: Types of waste used according to Cembureau [Cembureau 2006-5]

The waste used within the cement industry is quite diverse. Animal meat and fats comprise the largest amount, followed by Rubber & Tyres, Refuse derived fuel (RDF), solvent and related waste.

In addition Member States authorities from Hungary, Lithuania, Luxemburg, Cyprus, UK, Czech Republic[48] and Slovenia submitted the waste codes permitted in their cement plants (see Annex 2).

48 Czech Republic did not indicate the annual average permitted capacity in Table 23 as this information is not available in their permits (pers.com.).

2.5.1.2. Exemptions from monitoring requirements (air) in the cement industry

Article 11 (6): Periodic measurements of HCl, HF, SO_2

The number of periodic measurements per year ranges from one to four.

Table 24: Exemptions from Article 11 (6) according to CEMBUREAU

Substance	Number of plants measuring periodically[49]	% of total
HCl	109	67
HF	110	68
SO_2	64	40

The Czech authorities indicated that their exemption (one plant) reduces the monitoring of HCl and HF to two measurements per year.

According to the Slovak authorities three exemptions for HCl and HF were granted. One plant has to measure four times a year while two plants measure twice a year. This exemption was granted based on the proof “that the emissions of those pollutants can under no circumstances be higher than the prescribed emission limit values.” Those exemptions have to be added to the CEMBUREAU values as the Slovak Republic is not represented by the association.

Article 11 (7): Heavy metals, Dioxins and Furans

CEMBUREAU indicated no exemptions from the measuring requirement according to Article 11(7). Three plants monitor PCDD/F quasi-continuously and 25 monitor mercury continuously.

Article 11(2) a

> 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;

[49] According to CEMBUREAU continuous measurement is carried out for all three substances in 53 (HF) to 165 plants (SO_2). The number of plants indicated here exceeds the total number of plants identified. According to CEMBUREAU this is due to the fact that in a number of plants periodic and continuous measurements are carried out.

CEMBUREAU indicated periodical measurement for total dust, NOx, TOC and CO for a number of plants (see table below).

Table 25: Periodical measurement of Article 11(2)a substances according to CEMBUREAU

Substance	Number of plants measuring periodically	Number of plants measuring continuously	No of plant missing continuous measurement (max.-min)	% of total (max.-min)
Total dust	60	167	0	-
NOx	60	169	0	-
TOC	79	129	83-33	49-20
CO[50]	53	110	109-52-	33-68

The number of measurements per period ranges from one to four.

Since Article 11(2) a foresees continuous measurements for TOC and CO without the possibility for any exemptions, the plants reported in Table 25 are not in line with the requirements of the WID.

2.5.1.3. Exemptions from Emission limit values in the cement industry

The Lithuanian authorities specified that an exemption for the Dust ELV to 50mg/m³ until 01.01.2008 (according to Annex II.1.1) has been granted.

The UK authorities pointed out that they have granted exemptions from the emission limits for NO_x, SO_2 or TOC. In case of NOx this exemption is time-limited for wet cement kilns (according to Annex II.1.1.). In case of SO_2 and TOC the exemptions have been granted in accordance with Annex II.1.2 as the "presence of organic matter and pyritic sulphur in the raw materials used for cement clinker manufacture result in emissions of TOC and SO_2 which are independent of the incineration of waste." In the Czech Republic exemptions for SO_2 (400 mg/m³) and TOC (50 mg/m³) were granted.

> Annex II.1.1.
>
> Until 1 January 2008, exemptions for NOx may be authorised by the competent authorities for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value for NOx of not more than 1200 mg/m3.
>
> Until 1 January 2008, exemptions for dust may be authorised by the competent authority for cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value of not more than 50 mg/m3.

[50] The exact number of plants measuring TOC and CO only periodically could be estimated based on the information given by CEMBUREAU.

> Annex II1.2.
>
> Exemptions may be authorised by the competent authority in cases where TOC and SO_2 do not result from the incineration of waste.

All of the exemptions granted by the abovementioned Member States are foreseen in the WID (see box). In order to assess whether all prerequisites for those exemptions have been met (like output capacity, technology) a detailed technical evaluation of each case would have to be performed.

Article 7(5) Emission limit values (and associated monitoring requirements) for polycyclic aromatic hydrocarbons and other pollutants

The number of plants monitoring PAHs ranges between 55 and 62 plants according to CEMBUREAU. 24 of those plants comprise an ELV for this substance as well. The number of measurements ranges from two to four per year for PAH's.

Other pollutants are measured continuously by 19 plants and periodically (twice a year) by 38 plants. Upon those other pollutants at least PCB, Phenol and Zinc are measured by one plant each.

The Slovenian authorities specified that they have set ELVs for Benzene (5 mg/m^3), PAH (1mg/m^3) and NH_3 (30 mg/m^3). Those substances are measured once per year[51].

Specific provisions for water discharges from the cleaning of exhaust gases

According to CEMBUREAU there are no discharges of waste water from the cleaning of exhaust gases in the cement industry upon their members.

[51] Contradiction with the Cembureau data on other substances.

2.5.2. Lime industry

In December 2006 contact has been established with the European Lime Association (EULA). A questionnaire was submitted on 21 of December 2006 and a meeting was carried out in January 2007. All information provided in the chapters below stems from the data collection of EULA for the revision of the Cement and Lime BREF describing the permitting situation at the end of 2005 [EULA 2006-1, EULA 2006-2], contact with the respective Member States authorities and with EULA subsequent to the meeting mentioned before. Before going into detail of the data it has to be remarked that according to EULA the review of the existing permits granted to lime operations "*shows that the transposition of the WID into national law was subject to different interpretations Thus depending on the countries, permits for lime kilns were granted according to the special provisions:*

- *for cement kilns (annex II.1 of the WID),*
- *for combustion plants (annex II.2 of the WID),*
- *for industrial sectors not covered under II.1 and II.2* "[EULA 2006-1]

In Germany they are permitted according to the German WID transposition (17^{th} BImSchV) comprising the same ELVs for the Cement and Lime industry. According to the Swedish Authorities so far one plant has been permitted according to Annex II.1 and one will be. According to EULA lime kilns are partly considered as combustion installations in France.

It was indicated that 50 lime kilns in EU 27 co-incinerate waste[52]. The distribution of kilns within the European Union is shown in the tables below.

Table 26: No. of kilns with sufficient data sets for detailed evaluation

Country	No of Kilns	No of plants
Denmark	1	1
France	25	4
Germany	18	6
UK	3	2
Finland	1	1
Sweden	2	2
Total	50	16

The kilns in Finland and Sweden are not taken into account when analysing the permitting situation due to no or only fragmentary information[53].

52 [EULA 2006-1] and subsequent clarification by EULA and Member States leading inter alia to the removal of the two Czech lime plants from EULA's data collection as they are burning exclusively animal tissue waste (animal fat-tallow and bone meal) and are not considered to fall under the WID by the Czech authorities.

53 EULA objected to limit the following analysis to the first four Member States presented in Table 26, but the information provided concerning Finland and Sweden was not sufficient to incorporate it.

All following analysis is based on the information on 47 kilns in four Member States. It has to be remarked that all emission limit values indicated were originally marked by the symbol "<"as values being permitted to be smaller than the value indicated. Due to data treatment procedures this symbol had to be removed. The minimum/maximum array of ELVs indicated in the table below refers only to the range indicated by all kilns in total of the respective country.

According to EULA wet processes do not exist anymore in the European lime sector, therefore no information was submitted. Based on the data collection of 2005 no exemption from WID operating conditions could be identified.

2.5.2.1. Exemptions from monitoring requirements in the lime industry

Article 11 (6): Periodic measurements of Hydrogen chloride, Hydrogen fluoride and Sulphur dioxide

According to Article 11 (6) the periodical measurement of Hydrogen chloride (HCl), Hydrogen fluoride (HF) and Sulphur dioxide (SO_2) according to Article 11 (2)c "*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".*

The number of measurements is determined to two per year according to Article 11 (6) in relation with Article 11(2) c if during the first 12 months of operation every three months a measurement is being carried out.

Hydrogen Chloride

Following table shows the distribution of continuous and periodic measurement of HCl within the lime industry:

Table 27: HCl - Number of kilns and type of monitoring per Member State

Substance	Member State	Continuous	Periodic	Number of kilns measuring	Total number of kilns per country
HCl	Denmark	1		1	1
HCl	France	13	25	25	25
HCl	Germany		18	18	18
HCl	UK	3	3	3	3
	Total	17	46	47	47

The Danish plant is measuring continuously as required by Article 11(2)a.

In France and UK, periodic measurements of HCl (generally twice a year) as well as continuous monitoring of HCl are carried out even if the discontinuous measurements are not explicitly required in the permits.

For all German plants the possibility to reduce the measurement from two to one per year has been granted. According to the information available at EULA 14 of the 18 kilns were required to perform six measurements within the first 12 months. The requirements for the remaining 4 kilns were not specified.

How those plants have actually proven that they cannot exceed the prescribed ELVs under no circumstances was not clarified by EULA.

Table 28: HCl - Number of periodical measurement and range of average daily emission limit values

Twice per year				
Substance	Member State	Total number of kilns measuring	Minimum (in mg/m³)	Maximum (in mg/m³)
HCl	France	25	10	30
HCl	UK	3	200	200
Once per year				
Substance	Member State	Total number of kilns	Minimum (in mg/m³)	Maximum (in mg/m³)
HCl	Germany	18	10	20

Hydrogen fluoride

HF is exclusively measured periodically in the four countries regarded here.

Table 29: HF – Number of periodical measurement and range of average daily emission limit values

Twice per year				
Substance	Member State	Total number of kilns measuring	Minimum (in mg/m³)	Maximum (in mg/m³)
HF	France	25	1	4
HF	UK	3	8	13
HF	Denmark	1	2	2
Once per year				
Substance	Member State	Total number of kilns	Minimum (in mg/m³)	Maximum (in mg/m³)
HF	Germany	18	1	10

Within the German plants the possibility to reduce the measurement from two to one has been granted. According to the information available from EULA, 14 of the 18 German kilns were required to perform six measurements within the first 12 months. The range of permitted ELVs is quite large.

According to EULA the reasons for the general exemption of continuous monitoring of HF are as follows:

- "The fluorine content of limestone suitable for the production of quicklime is generally low,
- There are strict limitations of fluorine content in the waste fuels,
- Hydrogen fluoride is very easily captured by limestone / lime.

These factors explain why an overwhelming number of discontinuous HF measurements show that the HF concentrations in the flue gas are close or below the usual detection limits (i.e. 0.1 to 0.2 mg/Nm^3 or well below the WID ELV)."

Sulphur dioxide

Table 30: SO_2 - Number of kilns and type of monitoring per Member State

Substance	Member State	Continuous	Periodic	Number of kilns measuring	Total number of kilns
SO_2	Denmark	1		1	1
SO_2	France	25	25	25	25
SO_2	Germany	4	14	18	18
SO_2	UK	3	3	3	3
	Total	21	42	47	47

For France and United Kingdom kilns have been indicated in which continuous and periodical measurements are carried out. The Danish kiln and in Germany 4 of 18 kilns and measure SO_2 continuously.

Table 31: SO_2 - Number of periodical measurement and range of average daily emission values

Twice per year				
Substance	Member State	Number of kilns measuring	Minimum (in mg/m³)	Maximum (in mg/m³)
SO_2	France	25	50	67
SO_2	UK	3	440	2800
Once per year				
Substance	Member State	Number of kilns measuring	Minimum (in mg/m³)	Maximum (in mg/m³)
SO_2	Germany	14	50	150

Within the German plants the possibility to reduce the measurements from two to one has been granted. According to the information available at EULA all of the 14 kilns were required to perform six measurements within the first 12 months. The large differences of the ELVs within each country and among the countries are remarkable. They are significant higher if compared to other requirements of Annex II in particular the values in the UK are elevated. EULA specified that for "France, the differences in the SO_2 emission levels are explained by the manner that the mixing rule was applied to one plant but not to the others". According to the UK authorities the high ELVs "may be due to the high values of C_{proc}."[54]

[54] Pers. Com. UK authorities 21.08.2007.

Article 11 (7): Heavy metals, Dioxins and Furans

According to Article 11 (7) “ *The reduction of the frequency of the periodical 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.*”

According to EULA PCDD/F and the heavy metals are measured twice a year in Denmark, France and the UK. In Denmark and each monitoring campaign consists of two sampling and analyses.

Dioxins and Furans

Only Germany has granted permission to reduce the number of discontinuous measurement of Dioxins and Furans from two to one per year.

Table 32: PCDD/F - Number of periodical measurement and range of average emission limit values

Substance	Member State	Number of kilns measuring	Minimum (in ng/m^3)	Maximum (in ng/m^3)
PCDD/F	France	25	0,1	0,1
PCDD/F	UK	3	0,1	0,1
PCDD/F	Denmark	1	0,1	0,1
Once per year				
Substance	Member State	Number of kilns measuring	Minimum (in ng/m^3)	Maximum (in ng/m^3)
PCDD/F	Germany	18	0,1	0,1

Cadmium and Thallium

In the four countries regarded here Cd + Tl is exclusively measured periodically.

Table 33: Cd + Tl - Number of periodical measurement and range of average emission limit values

Twice per year				
Substance	Member State	Number of kilns measuring	Minimum (in mg/m^3)	Maximum (in mg/m^3)
Cd + Tl	France	25	0,05	0,05
Cd + Tl	UK	3	0,05	0,2
Cd + Tl	Denmark	1	0,05	0,05
Once per year				
Substance	Member State	Number of kilns measuring	Minimum (in mg/m^3)	Maximum (in mg/m^3)
Cd + Tl	Germany	17	0,05	0,05

Germany has reduced the number of periodical measurements to once per year.

If exemptions according to Article 11 (7) have been granted the measurements are to be carried out once every two years. In Germany this exemption has not been granted to its full extent as Cd + Tl are to be measured once per year[55]. For one of the German kilns no information about the measurement of Cd and Tl is available.

In the UK some kilns have been permitted ELVs for Cd+Tl higher than the ones laid down in Annex II.3.

Mercury

Table 34: Hg - Number of kilns and type of monitoring per Member State

Substance	Member State	Continuous	Periodic	Number of kilns measuring periodically	Total number of kilns
Hg	Denmark	0	1	1	1
Hg	France	0	25	25	25
Hg	Germany	4	18	18	18
Hg	UK	0	3	3	3
Total		4	47	47	47

One plant in Germany has indicated that the mercury emissions are measured continuously. Nevertheless the same plant has indicated also periodic measurements of Hg. This requirement stems from the measuring obligation in the 17.BImSchV[56].

Table35: Hg - Number of periodical measurement and range of average emission limit values

Twice per year				
Substance	Member State	Number of kilns	Minimum (in mg/m³)	Maximum (in mg/m³)
Hg	France	25	0,05	0,05
Hg	UK	3	0,05	0,1
Hg	Denmark	1	0,05	0,05
Once per year				
Substance	Member State	Number of kilns	Minimum (in mg/m³)	Maximum (in mg/m³)
Hg	Germany	18	0,03	0,03

Only Germany has reduced the number of periodic measurements.

If exemptions according to Article 11 (7) has been granted the measurements are to be carried out once every two years. In Germany this exemption has not been granted to its full extent as Hg has to be measured once per year.

In the UK some kilns have been permitted ELVs for Hg higher than the ones laid down in Annex II.

[55] Except for the one plant comprising of four kilns were no measurements have been indicated.

[56] Article 11 (1) 1 17.BImSCHV.

Sum of Heavy metals

Table36: Sum of Heavy metals - Number of kilns and type of monitoring per Member State

Substance	Member State	Con-tinuous	Number of kilns measuring
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V & Sn)	Germany	0	17
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V & Sn, Se, Te, Zn)	France	0	25
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	Denmark	0	1
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	UK	0	3
Total		0	46

Except for Denmark all other countries are measuring more heavy metals than required by the WID. For one German kiln no information on heavy metal ELVs or measurement requirement was indicated.

Table37: Sum of Heavy metals - Two measurements per year and average emission limit values

Twice per year				
Substance	Member State	Number of kilns	Minimum (in mg/m³)	Maximum (in mg/m³)
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V & Sn, Se, Te)	France	25	0,5	1
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V & Sn, Se, Te, Zn)	France	25	5	5
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	UK	3	2	4
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	Denmark	1	0,5	0,5

Table38: Sum of Heavy metals - One measurement per year average emission limit values

Once per year					
Substance	Member State	Number of kilns measuring	Total num-ber of kilns	Minimum (in mg/m³)	Maximum (in mg/m³)
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V & Sn)	Germany	17	18	0,5	0,5

The range of ELV for the French and UK kilns is diverse and cannot be compared since the measured heavy metals are different as well.

Article 7(5) Emission limit values for Polycyclic aromatic hydrocarbons and other pollutants

According to Article 7 (5) of the WID *“Member States may set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.”*

No emission limit values have been reported by EULA for the lime industry. The only other pollutant apart from the additional heavy metals shown above has been ammonia being regulated by Germany.

2.5.2.2. Waste type used for co-incineration in the lime industry

Following table shows exemplary waste being used in Lime kilns for co-incineration. Where specified by EULA the nomenclature of the European waste list (EWL) was indicated.

Table 39: Reported types of wastes co-incinerated in Lime kilns

Country	Number of plants using secondary fuels	EWL Code	Type of waste
Czech Republic	2		Burnable substances (plastics, paper, textile, rubber …)
Denmark	1		Bone meal
			Animal flour
France	25		Waste oils
			Xylene based solvent
			Toluene based solvent
		12/13 00 00	Waste oils
		02, 03, 05-08, 12-14, 16, 17 00 00	Water + hydrocarbon oils
			Paper
			Residues from municipal waste (except PVC)
			Plastic residues (except PVC)
			Non impregnated sawdust
			Tyres, non chlorinated rubber
		17 02 00	Building and demolition waste
		07 02 00	Polymers waste
Germany	18		Residues from municipal waste
			BPG 3.1, 3.2, 2. (combustible production residues)
			Waste oil[57]
Sweden	2		Waste oil
United Kingdom	3	19 02 08	Solvent Derived Fuel

Requirements for waste co-incineration

Following table shows requirements towards waste being used in Lime kilns for co-incineration.

[57] [UBA 2005a] Information stemming from the study for the German Environmental agency: Material flow analysis and market survey for securing the disposal of waste oils, Ökopol 2005.

Table 40: Reported input requirement of secondary fuels into lime kilns

Country	Number of plants using secondary fuels	Permitted capacities for secondary fuels	% of resulting heat release range Hazardous wastes	% of resulting heat release range + Non hazardous wastes	Requirements for waste input
Czech Republic	2	nothing indicated	nothing indicated	25%	Net calorific value: 20 < X < 24
Denmark	1	0,4 t/h	nothing indicated	8% to 12%	nothing indicated
Finland	1	nothing indicated	nothing indicated	nothing indicated.	nothing indicated
France	25	< 266.575 t/year (one kiln missing information)	< 40%	<15%, 33%, missing information about two kilns	Net calorific value higher than 8, 10, 18 or 27; but lower than 29 (maximal value indicated for two kilns)
Germany	18	4.56 < X < 5.65 4.87 < X < 6.14 5.89 < X < 7.07 < 2 for four kilns (in t/h) [58]	nothing indicated	2 kilns 50% 3 kilns 60% 3 kilns 70% 10 kilns 100%	Net calorific value for three kilns (in MJ/kg)[59]: 25 < X < 31 23 < X < 29 20 < X < 24
Sweden	unclear	< 27.000 t/year (indication by two plants	20 % (one plant)	100% (one plant)	nothing indicated
United Kingdom	3	< 130.000 t/year	25-40%	not applicable	20 < X < 33.25 20.5 < X

The information is not comprehensive and in case of the permitted capacity different units have been used. In most countries minimum and maximum net calorific values are part of the permit for waste co-incineration.

Taking into account only the information of France, Sweden and the UK the MS having most kilns (leaving out Germany) the permitted capacity for waste amounts to 444.696 t per year. EULA specified that the actual used amount of waste amounts to 262,000 t a year based EULA estimates for 2005.

[58] For some kilns the amount of wastes has to be within a certain range per hour in order to be introduced into the process.

[59] For some kilns the net calorific value of the waste has to be within a certain range in order to be co-incinerated within the process

2.5.3. Various industries

This chapter summarises the outcome of the data collection via questionnaire which was sent to the national authorities of all 27 Member States on 28th December 2006 announcing end of January 2007 as the deadline of the first part of the questionnaire and end of February 2007 as deadline for the second and third part. Unless otherwise stated the information stems exclusively from the Member States authorities.

The following table shows the number of existing and new plants of different industry sectors which were reported as permitted according to the Waste Incineration Directive by 23 Member States[60] which replied. The MS questionnaire already listed three specific sectors of co-incineration (production of energy, ferrous metals, non-ferrous metals) and gave the opportunity to add "others". The Member States added the following sectors:

- Ceramics/ clay aggregates
- Chemical/Polymers
- Cement[61]
- Lime[62]
- Fertiliser
- Food
- Waste oil incineration plants
- Pulp and Paper
- Wood industry

[60] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden, UK. The German is not complete as it stems only from three sources covering only two co-incineration sectors. The Belgium data stem from the Flemish authorities and is not complete either. According to Maltese authorities no co-incineration is carried out on Malta.

[61] The information on cement plants given here stems from the Member States and is joined with the information from chapter 2.5.1 regarding the number of plants.

[62] The information on lime plants given here stems from the Member States and is joined with the information from chapter 2.5.2 regarding the number of plants.

Table 41: Reported number of plants co-incinerating waste per sector, type and permitting status

Plant Type	Number of plants falling under the Waste incineration Directive					
	Sum of plants	Sum of permitted plants	Sum new plants	Sum new permitted	Sum existing plants	Sum existing permitted
Cement	124	122	1	1	123	121
Ceramics	6	5			6	5
Chemical	4	4			4	4
Energy industries (combustion plants)	193	181	21	21	172	160
Ferrous metal industry	4	4			4	4
Fertiliser	2	2			2	2
Food	1	1			1	1
Lime	11	9	4	2	7	7
Non-ferrous metal industry	6	6			6	6
Pulp- and paper industry	19	19	4	4	15	15
waste oil incineration plants[63]	10	10			10	10
wood industry	14	14	2	2	12	12
other sectors	389	127			389	127
Total	**783**	**504**	**32**	**30**	**751**	**474**

In total 783 co-incineration plant were reported by 23 Member States. Only 4% of those plants have been identified as new plants. 279 have not yet been permitted according to the requirements of the WID. Additionally 389 existing plants which are falling under the WID could not be specified concerning their industry sector. The majority (384) of these are mentioned by Italy. It is also in Italy where only ~ 30% of those plants have been permitted according to the WID being therefore the main reason for the aforementioned implementation gap. If those 389 “unknown” plants would be deducted from the total number of plants and total number of permitted plants, only 17 plants would be missing a permit according to WID as opposed to 279 plants if including the unknown sectors.

The following information stems from Associations, publications or individual companies is added for those MS where information about this industry has not been indicated is presented below.

[63] The main purpose of those plants is to produce energy but since they only use waste oil for co-incineration they have been mentioned in an extra entry in table Table 41.

Number of plants permitted according to the WID and the IPPC-D

20 MS[64] responded to the question on how many of the **co-incineration plants** are falling both under the Waste Incineration Directive and under the IPPC Directive.

In following 11 countries all WID co-incineration plants are also permitted under IPPC: Cyprus, Denmark, Estonia, Hungary, Ireland, Latvia, Luxembourg, Romania, Slovak Republic, Sweden and UK. Except for the Slovak Republic half of the plants are existing plants and half are new plants. In the Slovak Republic one existing IPPC plant was still not permitted according to IPPC.

In following Member States the number of WID plants is slightly higher than IPPC plants: France (+1), Netherlands (+1), Finland (+3), Spain (+9), Lithuania (+1) and Slovenia (+1).

In Spain 8 permits are still missing, in Slovenia two, in Lithuania one and in the Netherlands also one.

2.5.4. Reported number of co-incineration plants

Whenever figures are given these relate to plants identified through the data gathering exercise in the sector concerned which are co-incinerating waste and are covered by a WID permit.

Cement industry

In total 124 plants falling under the WID have been identified by 19 Member States[65]. Except for one Irish plant, all permitted cement plants indicated by the Member States have been permitted as existing plants. 2 plants in Sweden have not yet been permitted according to the WID but are within the permitting process. In addition Spain indicated five cement plants in three regions[66] but did not specify their permitting situation. In Germany approximately 33 cement plants are permitted according to the WID.

According to CEMBUREAU there are also cement plants co-incinerating waste in Belgium, Finland, Poland, Greece, Portugal and Italy. In total CEMBUREAU identified 162 plants to be covered by the WID in 22 Member States and one EEA Country[67]. 17 of them permitted as being new and 145 permitted as existing waste co-incineration plants. All of them are covered by the IPPC Directive.

[64] Austria, France, Netherlands, Finland, Lithuania, Slovakia, Slovenia, Spain, Czech Republic, Cyprus, Denmark, Estonia, Hungary, Ireland, Latvia, Luxembourg, Romania, Sweden, UK, Italy, Poland.

[65] Austria, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, France, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Romania, Slovakia, Slovenia, Sweden, UK and Germany. The German data stem from following study: "Implementation status of the waste incineration directive in Germany according to the national implementation (17.BImschV) with regard to Dust and NOx in cement plants" carried out by Ökopol for the German Federal Environmental Agency. The study will be published in the course of 2007.

[66] Valencia, Galicia and Cantabria.

[67] The data covered following Member States: Austria, Belgium, Netherlands, Luxembourg, Czech Republic, Denmark, Finland, Sweden, Ireland, Estonia, Latvia, Poland, Hungary, France, Germany, Greece, Portugal, Romania, Slovenia, Italy, Spain, United Kingdom. The data also comprised information about Norway.

The actual number of plants per Member State was not indicated by CEMBUREAU.

Even though the data set of the Member States authorities and CEMBUREAU cannot be compared directly as they comprise information about different countries[68], an average value of 143[69] cement plant was taken in order to include the information about the cement plants.

Ceramic industry

Six existing plants belonging to the ceramic industry[70] were reported by the Member States. Five of them are permitted according to the WID (Estonia, Sweden and Spain). The IPPC permit of the Lithuanian plant will be soon adapted to the requirements of the WID.

Flanders reported 4 plants but did not specify their permitting situation[71]. In addition to this EXCA reported 8 kilns in approximately 7 plants with WID permits in Denmark, Finland, Italy Portugal and Poland. They also identified several Member States[72] having Expanded Clay plants but no WID permit as the waste used is classified as secondary raw material or as pore forming additive.

Therefore, the reported minimum number of plants co-incinerating waste in the ceramic industry amounts to 17 plants.

Chemical industry

Four existing plants belonging to the chemical industry have been reported by the Member States that are permitted according to the WID: one plant in Ireland, one in the Netherlands and two in Sweden[73].

Energy industry

A total of 193 combustion plants belonging to the energy industry have been reported by 13 Member States[74], thereof 172 are considered as existing and 21 as new installations. The majority of existing plants have been reported in Italy with 103 plants followed by the UK with 28 plants. Two of the Italian plants are still to be permitted according to the WID. The majority of new plants can be found in Sweden (9 plants) and Finland (6 plants).

In Spain none of the 10 existing plants have been permitted according to the WID yet.

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68 Cembureau incorporated also data for Norway and the Member States authorities indicated WID cement plants also for Lithuania and Cyprus.

69 Cembureau indicated between 162 to 167 installations, including Norway. Since Cembureau did not specify the number of plants per country (for market protection reasons) a detailed comparison per country could not be carried out in order to determine the real number of cement plants in EU 27.

70 Including „clay aggr." as indicated by Sweden.

71 Email Ovam 22.06.07.

72 Austria, Belgium, Czech Republic, Germany.

73 CEFIC answered in May 2007 that they are not able to provide information about the co-incineration of waste in the chemical sector.

74 Austria, Denmark, Flanders, Finland, France, Hungary, Ireland, Italy, Netherlands, Slovenia, Sweden, UK, Spain.

One German publication from 2002[75] indicates at least 12 power plants with the permission to co-incinerate sewage sludge and approximately 6 power plants to co-incinerate other waste. The total number of combustion plants is therefore estimated to be 211.

Ferrous metal industry

Austria and Luxembourg indicated two existing plants in this industry sector. The Luxembourg plant is an electric arc furnace and the Austrian plant a blast furnace (for details see chapter 3.11 and 4.10). All plants of the steel industry are permitted according to the IPPC Directive.

Lime industry

11 lime plants have been identified by the Member States that are permitted according to the WID: France 4 plants, Sweden 4 plants, Denmark one plant and the UK 2 plants. Except for the Swedish plants all are permitted as existing plants.

In addition to this EULA identified six plants in Germany and one in Finland. According to EULA all of those plants are also permitted according to the IPPC Directive.

All identified lime plants co-incinerating waste are adding up to 18 plants[76].

Non ferrous metal industry

Six existing plants that co-incinerate waste and belong to the sector "non-ferrous metal industry" have been identified: Germany 3 plants, Austria 2 plants and Sweden 1 plant. The German plants are small precious metal re-covery plants with very low annual waste input[77] (for details see chapter 2.5.10)

Paper and Pulp industry

Sweden, Austria, BE-Flanders and the Netherlands have indicated 19 paper and pulp plants that co-incinerate waste.

In addition CEPI has indicated another 11 pulp & paper plants being permitted under the WID in 3 Member States which have not answered the questionnaire or did not indicate these plants.

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[75] Richers, U , et al : Present status and perspectives of co-combustion in German power plants, Forschungszentrum Karlsruhe, Wissenschaftliche Berichte, FZKA 6686, 2002.

[76] The number of plants indicate in chapter 2.5.2 stemming from EULA amount to 16 plants. However the number of kilns is much higher (~ 50).

[77] No information are available regarding the type of the other installations.

Table 42: CEPI information on the number of paper and pulp plants permitted under the WID

	total permitted under WID	Permitted under WID and IPPC
Finland	5 (existing)	5
Germany	Max 32, exact number unclear	unclear
Italy	2	2
United Kingdom	4	3

[CEPI 2007[78] adapted by Ökopol]

Furthermore CEPI stated that they know of plants in the Czech Republic France, Hungary, Slovakia and Sweden but indicated that those plants do not fall under the WID as they either incinerate waste which is exempted or are using "internal residues".

The number of paper and pulp plants in Europe co-incinerating waste amounts at least to 30.

Waste oil incineration plants

10 Waste oil incineration plants have been identified in Austria. All of those existing plants have been permitted according to the WID.

Wood industry

14 plants belonging to the wood industry that co-incinerate waste have been indicated by the Member States, thirteen in Austria (2 new) and one in the Netherlands.

Others

Two existing fertiliser plants and one existing plant in the food industry have been indicated and permitted according to the WID by Spain.

389 existing plant which are falling under the WID could not be specified concerning their industry sector, the majority (384) of which are mentioned by Italy. Here only ~ 30% of those plants have been permitted according to the WID. One "other" plant was in Denmark and four in Spain. Spain is lacking 10 combustion plants at least[79]. Those unknown plants have a particular impact on the number of plant missing a permit according to WID.

[78] Letter from CEPI dated 12.04.2007, subject: Revision of the Waste Incineration Directive (WID).
[79] as only 6 replies from 19 regions were made available.

Summary

Taking all this information into account following distribution of sectors is available summing up to a total of 849 co-incineration plants[80] leaving the unidentified industry sector as the largest co-incineration sector, followed by the cement and energy industry.

Table 43: Distribution of co-incinerating sectors based on submitted data

	PlantType	Number of plant	Total
Co-incineration	Cement	143	849
	Ceramics	17	
	Chemical	4	
	Energy industries (combustion plants)	211	
	Ferrous metal industry	4	
	Fertiliser	2	
	Food	1	
	Lime	18	
	Non-ferrous metal industry	6	
	Other sectors (co-incineration)	389	
	Pulp- and paper industry	30	
	Waste oil incineration plants	10	
	Wood industry	14	

The percentage distribution of all plants in shown in Figure 5.

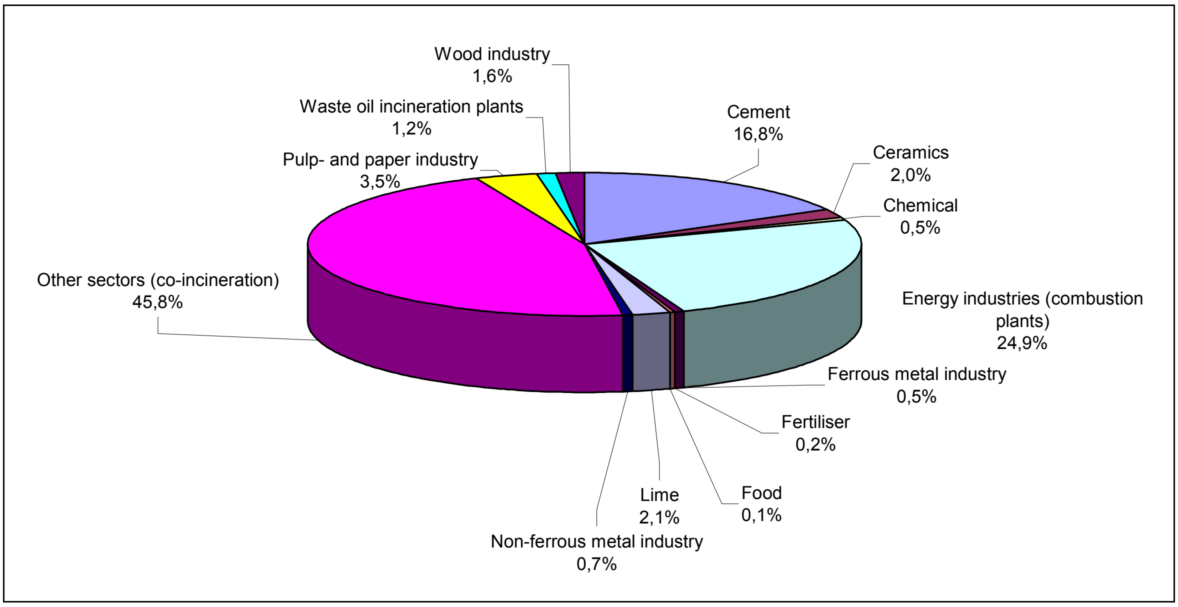

Figure 5: Distribution of co-incinerating sectors based on submitted data

80 For the Cement industry the mean of Cembureau's and MS information has been taken into account (143 plants).

The detailed data for the number of new and existing co-incineration plants per Member State can be found in Annex 2.

Following chapters provide information from the Member States on the co-incineration sector except the cement and lime industry as those sectors have been specifically investigated in chapter 2.5.1 and 2.5.2.

2.5.5. Operating conditions different to standard requirements regarding temperature of combustion and residence time

The Member States have been asked in the questionnaire: *“Operating conditions: Please indicate the number of permits for which, in accordance with Article 6(4) of the Directive, conditions different to the standard requirements for the temperature and duration of combustion have been authorised for co-incineration plants. Please describe the exemptions and the reasons for them.”*

17 Member States provided answers to this question: Austria, Bulgaria, Estonia, Finland, France, Germany Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Slovenia, Spain, Sweden and UK. 28 cases with exemptions were reported

Table 44: Reported number of exemptions from operating conditions by Member State

Country	**Number of Exemptions**
France	2
Ireland[81]	1
Sweden	2
UK	22
Germany	1
Sum	**28**

France, Ireland and the UK granted exemption for residence time. Only Sweden granted also an exemption from the required temperature. For the one German plant an exemption from the operating conditions of article 6 (2) has been granted “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.”

[81] The exemption of the Irish plant will cease in 2007

France gave the reason that the installation (Boiler) is not constructed in a way to allow the required residence time. The Swedish plant complies with all WID-ELVs and therefore auxiliary oil burning was not considered "give any environmental benefits"[82].

The UK described their exemptions as follows: "The TOC/LOI in bottom ashes have to be measured and the levels have to be compliant with those required by WID and associated with BAT to ensure that no more residues are produced compared to, and that the content of organic pollutants in those residues is no more than expected from, a non-exempted plant. Regarding the operating conditions laid down in the permit: Where derogation under Article 6(4) is sought, the applicant is required to demonstrate in their application that this will not give rise to exceedances of relevant emission limits etc.. If this can be demonstrated, then the installation is authorised at those operating conditions. The permits require that all WID requirement (except those derogated) are met at all times."

Austria stated that such information will be only available in the second half of 2007.

In Italy this data could not be made available as "the Region is the Competent Authority for the permit of co-incineration plants".

2.5.6. Implementation of exemptions concerning NOx and SO_2 limit values

The Member States have been asked in the questionnaire: *"Implementation of the exemptions for the emission limit values (ELVs) set down in Annex II 2.1. for combustion plants concerning NOx and SO_2: How many exemptions have been granted? Please describe or give examples of the exemptions and the reasons for them."*

Answers were received from 15 Member States: Austria, Bulgaria, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden, and UK.

Finland and Slovenia have granted one exemption each. Finland indicated that since waste co-incineration is new, the authorities need experience "to determine where addition emission control measures are needed". Slovenia did not indicate a specific reason.

The Austrian Incineration Ordinance has no possibility for such exemptions.

UK only answered regarding cement industry. Their data will be evaluated in chapter 2.5.1.

[82] Auxiliary burning would have been necessary in order to reach the minimal temperature. Since the ELV were met the authorities abstained from further measures

2.5.7. Air emission limits for PAH's and other pollutants

The Member States have been asked in the questionnaire: *"Usage of Article 7(5). Air emission limit values for PAH's and other pollutants: "How many permits include ELVs for PAHs and other pollutants? b) What emission limit values (or ranges of values) have been set? Please give the substances, units and reference periods. Please describe the monitoring requirements (continuous/discontinuous monitoring, applied standards, etc.)."*

14 Member States replied: Austria, Bulgaria, Estonia, Finland, France, Hungary, Ireland, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden, and UK. (see the following tables).

Table 45: Air emission limits for other pollutants by Member State

Country	Substance	Measurement	Half hour average (mg/m³)	Maximum load (kg/h)	Number of permits
Austria	Benzo(a)pyren; PCB, NH_3	-	-	-	2
Netherlands	HCN	continuous	2	0.4	1
	Acetonitril		1	0.2	
	CAN		1	0.2	
	Acrolein		1	0.2	
UK	NH3	periodic	10-20	-	3
Luxembourg	PCB	Discontinuous twice a year	0.001		1

Table 46: PAH as parameter in the permitting process

Country	Measurement	Measurement conditions	Sampling period	ELV (mg/m³)	Number of permits
Austria	no information	Dry gas, 0°C, 1013 mbar, 11 % Oxygen	3-16 h	0.01	2
Italy	Discontinuous	no information	8 h	0.01	Any (co-) incineration plant
Luxembourg	Discontinuous twice a year	no information	no information	0.05	1

In the UK "all incineration and co-incineration plants are required to monitor specified PAHs but no ELVs have been set".

2.5.8. Emission limit value for waste water from exhaust gas cleaning for PAH's and other pollutants

The Member States have been asked in the questionnaire: *"Usage of Article 8(8). Emission limit values for waste water from exhaust gas cleaning for PAH's and other pollutants: "How many permits include ELVs for PAH's and other pollutants? What emission limit values (or ranges of values) have been set? Please give the substances, units and reference periods. Please describe the monitoring requirements (continuous/discontinuous monitoring, applied standards, etc.)."*

13 MS replied: Austria, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Sweden, Spain and UK.

Only for two Austrian combustion plants NH_4, COD, TOC and other substance not further specified were indicated to be measured twice a year. Only Italy has permitted PAHs having following requirements “ELV of 0.0002 mg/l of PAH for any incineration and co-incineration plant has been established. Analysis is performed on unfiltered sampling. Frequency of the monitoring: six months, three months during the first year”.

Estonia, Luxembourg, Slovenia and the Netherlands indicated that there are only dry processes for the respective plants.

2.5.9. Specific provisions for water discharges from the cleaning of exhaust gases

The Member States have been asked in the questionnaire: *“Have specific provisions been set out according to Article 8(3) of the Waste Incineration Directive? If yes, please describe those provisions and in particular the permitted ELV's. Have any exemptions for ELVs for total suspended solids according to Annex IV been granted? If yes, please indicate the number of exemptions and the reasons for them.”*

14 MS answered with regard to **provisions** set for water discharges from the cleaning of exhaust gases: Austria, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden and UK.

Except for Austria and the UK, no MS has set out specific provisions according to Article 8 (3)

Austria has harmonised their national waste water ordinance for exhaust gas with the WID requirements. The requirements are seen by Austria as slightly too strict to achieve them simply by sedimentation without supplementary cleaning step. Austria questioned that this will actually lead to any additional installation of such a cleaning step as the effort is considered to be too high.

The UK replied that “the ELVs have been set in accordance with Annex IV (or by using the Annex II mixing rule where the effluents are combined)”. Although the mixing rules requirement of Annex II are meant to be used for air emissions only, apparently the UK are using the same procedure also for water emissions.

Estonia, Luxembourg, Slovenia and the Netherlands indicated that there are only dry processes for the respective plants.

14 MS answered with regard to **exemptions** set for water discharges from the cleaning of exhaust gases: Austria, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden and UK.

Only Finland indicated an exemption for one plant according to Article 11(6) since “new running models for a waste water treatment plant are still under development”.

Austria could not provide any data so far. Only the four combustion plants situated in Austria indicated that all water related emissions are measured periodically four times a year. ***Therefore the requirements for monthly measurements of heavy metals and the daily measurements of TSS are not followed.***

2.5.10. Exemptions for the monitoring requirements of HCl, HF and SO_2

The Member States have been asked in the questionnaire: *“Implementation of the exemptions for the monitoring requirements of HCl, HF and SO_2 according to Article 11(6): How many exemptions have been granted? For which type of installations have these exemptions been issued? Please describe or give examples of the exemptions and the reasons for them.”*

14 MS replied: Austria, Bulgaria, Germany, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Netherlands, Slovenia, Spain, Sweden, UK,

Austria stated that detailed data about the number of exemption will only be available in the second half of 2007 but information for four Austrian plants could be made available through EURELECTRIC.

Besides Austria the Member States Finland, France, Germany, Hungary, Ireland, Netherlands, Slovenia, Spain, Sweden and the UK indicated exemptions according to Article 11(6).

Table 47: Reported exemptions from Article 11(6)

Name	No of exemptions	Installation type	Substances measured periodically (number of permits)	Reasons
Austria	7	Combustion plant	HCl (3), HF (4)	According to the Ministry continuous measurement of HF is not necessary if treatment steps for HCl are applied which assure the conversion of HCl/HF into alkaline earth metal halides and therefore making sure that the remaining HCl/HF emissions are only 30% of its respective ELV.
Finland	2	Power plants	not specifically indicated	lower emissions than WID- ELVs
France	2	Boiler	HCl, HF	Feed waste cannot contain fluorine or chlorine based compounds; exhaust treatment of HCL guaranteed
Hungary	1	Power plant	not specifically indicated	High cost of continuous monitoring
Ireland	1	Power plant	HCl, HF	Feed waste cannot contain fluorine or chlorine based compounds
Netherlands	1	Co-incineration plant for waste water and chemical waste	Maximum limits for the input of sulphur, chloride and fluoride; Strict monitoring on the input	Very Low content of Sulphur, Chloride en Fluoride in the Waste Water and Chemical Waste
Slovenia	2	Combustion plants	periodic measurements of HCl, HF (1) HCl, HF, SO2 (1)	Emission are not higher than WID ELV's
Spain	2	Fertilizer plants	HCl, HF	Only waste oil is used
Sweden	3	2 heat plants; 1 cogeneration plant burning “clean" biomass and wood waste	HCl, HCl/HF	Operators have shown emissions cannot exceed ELVs.
UK	15	Combustion plant	HCl/HF, SO2 (7), HF (8)	Plants showed that their waste composition will not lead to an exceedance of the ELVs
DE	2	Precious metal recovery	HCl, HF, SO2	Only 340 t of waste are used per year, ELVs have been further reduced

In total 38 exemptions have been granted within 10 Member States, the majority of them in the UK.

2.5.11. Exemptions for the monitoring requirements of dioxins and furans

The Member States have been asked in the questionnaire: *Implementation of the exemptions for the monitoring requirements of dioxins and furans according to Article 11(7). ”How many exemptions have been granted? For which type of installations have these exemptions been issued? Please describe or give examples of the exemptions and the reasons for them.”*

15 MS Replied: Austria, Bulgaria, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden, and UK.

Ireland indicated one reduction in the monitoring requirements for dioxins/Furans for one power plant. In details the "licence allows that the company reduce monitoring should the levels be demonstrated to be negligible. Also company cannot utilise any wastes that may contain halogenated organics." The number of measurement was not indicated by Ireland.

Germany indicated exemptions for two precious metal recovery plants as they use a low amount of waste per year and their ELV have partly been reduced if compared to the national implementation of the WID.

According to Austria no exemption possibilities are foreseen in the national implementation of the WID.

2.5.12. Exemptions for the monitoring requirements of heavy metals

The Member States have been asked in the questionnaire: *"Implementation of the exemptions for the monitoring requirements of heavy metals according to Article 11(7): "How many exemptions have been granted? For which type of installations have these exemptions been issued? Please describe or give examples of the exemptions and the reasons for them."*

Replies were received from 15 MS: Austria, Bulgaria, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden and UK

Only three Member States indicated exemptions according to Article 11(7).

Ireland indicated one reduction in the monitoring requirements for heavy metals for one power plant based on the fact that heavy metals are not part of the waste input. The number of measurement was not indicated by Ireland.

The Netherlands have granted also one exemption according to Article 11(7) for a co-incineration plant for waste water and chemical waste. This exemption has been granted based because the he waste input is strictly monitored.

Germany indicated exemptions for two precious metal recovery plants as they use a low amount of waste per year and their ELV are partly lower if compared to the national implementation of the WID.

According to Austria no exemption possibilities are foreseen in the national implementation of the WID.

2.5.13. Continuous measurement of heavy metals

The Member States have been asked in the questionnaire: *“Continuous measurement of heavy metals in air emissions according to Article 11(13) of the Waste Incineration Directive: Are heavy metals continuously measured in some plants and if yes in how many?”*

Replies were received from 14 Member States: Austria, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden and UK.

Only Austria has indicated that continuous measurement of Hg is required by the national implementation of the WID. Detailed data will be available in the second half of 2007.

2.5.14. Permitted capacity for waste co-incineration

The Member States have been asked in the questionnaire: *“Please indicate the annual average permitted capacity for burning wastes (in tonnes).”*

14 answers were provided by the following Member States Austria, Estonia, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Slovenia, Spain, Sweden, UK.

Table 48: Reported permitted capacity for waste co-incineration (without cement & lime) reported by the Member States

Country	Permitted capacities per year (in t)	Remarks
Austria	4 000 000 - 5 000 000	Includes probably wastes no covered by WID
Belgium		No data
Denmark		No data
Estonia	20 000	
Finland	131 080	
France	3 800	
Germany		No data
Greece		No data
Hungary	400 000	
Ireland	3 300	
Italy		No data
Lithuania	7 500	
Luxembourg	5 000	Test run in 1 plant in 2006/2007
Netherlands	7 871	Incomplete information
Poland		No data
Portugal		No data
Slovenia	40 170	
Spain	5 776	Incomplete information (6 of 19 regions, two plants in total)
Sweden	10 000 - 300 000	
UK	2 140 000	
Sum	**6.8 – 8.0 million**	

Looking at the distribution of the co-incineration plants in Table 41 it is most likely that most of the waste indicated in the table above is co-incinerated in the energy sector.

Lithuania indicated that only 3490 t of waste have actually been used in 2005 (against 7,500t permitted capacity per year). Sweden indicated that the actual waste input varies between 50,000 t/y and 100,000 t/y (against the permitted 10,000 to 300,000t per year).

2.5.15. Types of wastes co-incinerated

The Member States have been asked in the questionnaire: *"Please indicate the type of waste burned according to the nomenclature of the European list of waste (e. g. 13 02 05* mineral-based non-chlorinated engine, gear and lubricating oils)"*

14 MS indicated the types of wastes co-incinerated (see figure below).

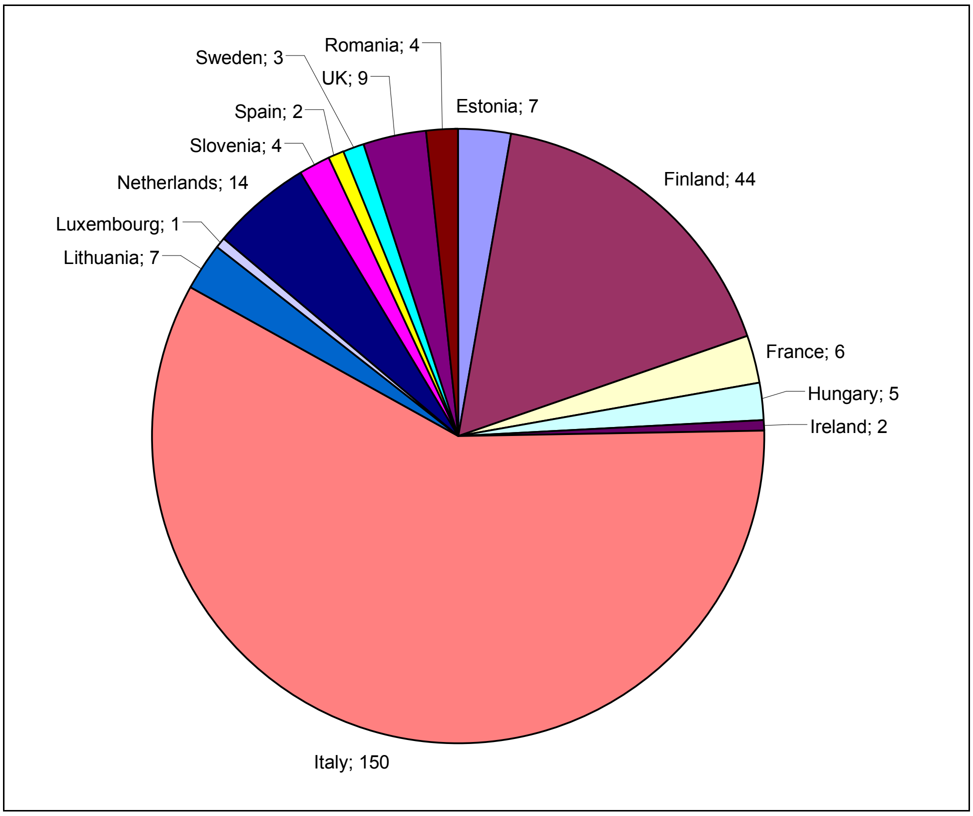

Figure 6: Number of wastes codes indicated per country

More than 200 waste codes were submitted being differentiated into 173 different six-digit waste codes for co-incineration[83], 98 of them are hazardous wastes.

Italy indicated the majority of waste codes (149).

No waste codes from the following two digit headings were indicated:

- wastes resulting from exploration, mining, quarrying, physical and chemical treatment of minerals (code 01) and
- wastes from thermal processes (code 10).

[83] except cement & lime industry.

Mostly following two digit waste codes were indicated:

- Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing (code 02),
- Wastes from organic chemical processes (code 07),
- Oil wastes and wastes of liquid fuels (except edible oils, 05 and 12) (code 13),
- Wastes not otherwise specified in the list (code 16),
- Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use (code 19).

The waste code numbers 07 and 16 were predominantly indicated by Italy.

Following four digit waste codes were mostly indicated:

- Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing (Code 02 01),
- Wastes from the MFSU of pharmaceuticals (code 07 05),
- Wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation) (code 19 02),
- Wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified (code 19 12),
- Separately collected fractions (except 15 01) (code 20 01).

The detailed waste codes used by the Member States and additional waste codes for the cement industry can be found in Annex 2.

2.5.16. Summary on the implementation of the WID in the co-incineration sector

Reported number of plants and permit status

The distribution of all plants in shown in the figure below.

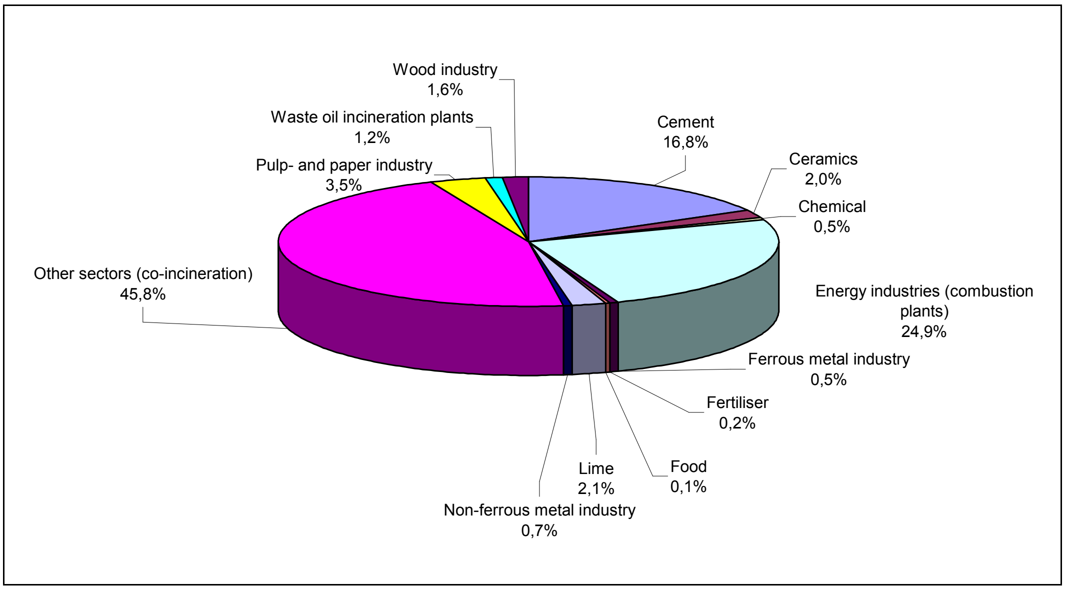

Figure 7: Distribution of co-incinerating sectors based on submitted data

Following distribution of sectors is available summing up to a total of 849 co-incineration plants[84] leaving the unidentified industry sector as the largest co-incineration sector, followed by the cement and energy industry. Nearly all of those plants (~ 96%) are existing plant according to Article 3(6) of the WID. 38% have not yet been permitted according to the requirements of the WID and in addition about 50% of the plants falling under the WID could not be specified concerning their industry sector. The majority of which are mentioned by Italy. It is also in Italy were only ~ 30% of those plants have been permitted according to the WID being therefore the main reason for the aforementioned implementation gap.

Over 90% of the co-incineration plants are covered by IPPC and WID at the same time. In some Member States IPPC permits are still due.

[84] For the Cement industry the mean of Cembureaus and MS information has been taken into account (143 plants).

Waste amounts

13 Member States have reported the permitted average capacity to be between 6.8 and 8.1 million tonnes for the co-incineration sector except cement and lime. The overall amount is largely influenced by the figures reported by Austria and UK.

Data uncertainty of the overall waste amounts is high due to the fact that information from eight Member States is missing, two countries submitted incomplete data and some implausibilities remained for the delivered data.

The total amount of waste co-incinerated in the cement industry was 6.2 million tonnes in 21 MS and Norway. For the lime industry, the amount of waste co-incinerated in 2005 amounts to 262,000 t a year.

In total, the reported amount of waste being co-incinerated yearly amounts to at least **13 million tonnes**. However, high data uncertainty is related to this figure.

Exemptions from operating conditions

Regarding exemptions on operating conditions five Member States have granted exemptions predominantly on the residence time of the waste gases at the minimum temperature (850 °C or 1100 °C).

Additional ELVs

Regarding the implementation of exemptions concerning NO_x and SO_2 limit values for combustion plants, two of 15 Member States have granted such exemptions.

Air emission limits for PAHs and associated monitoring according to **Article 7(5)** are required by a few Member States (AT, IT, LU). The ELVs set range from 0.01 to 0.05 mg/m³. About 36% of the cement plants are monitoring PAHs and about 15% are measuring PAH's periodically. No measurements or emission limit values have been reported for the lime industry.

In total seven other pollutants are measured in four Member States (AT, NL, UK, LU). 35% of all cement plants are measuring also other pollutants like PCB, phenol and zinc. The only other pollutant apart from the additional heavy metals has been ammonia being regulated by Germany.

Additional water emission limit values for PAHs according to **Article 8(8)** have been set only by one Member State out of nine MS having wet processes for incineration and co-incineration plants. A number of other pollutants are measured in two Austrian plants.

Specific provisions for water discharges from the cleaning of exhaust gases according to **Article 8(3)** have been reported by two Member States (AT, UK) out of 10 having wet processes. Exemptions for the measurement requirements have been reported by two Member States (FI, AT).

In the cement and lime industry there are no discharges of waste water from the cleaning of exhaust gases.

Exemptions from monitoring requirements or ELVs

Exemptions for the monitoring requirements for HCl, HF and SO_2 according to Article **11(6)** have been reported by 10 Member States. Main reasons for these exemptions was evidence that waste input does not contain or not sufficiently contains sulphur, chlorides or fluorides to exceed the WID ELVs. About 60% of all cement plants are exempted from the continuous monitoring of HCl, HF and SO_2. At the same time a number of plants are measuring those substances also continuously. In the French and British lime plants periodic measurements as well as continuous monitoring for all substances falling under Article 11(6) are carried out even if the discontinuous measurements are not explicitly required in the permits.

For almost all German lime plants the possibility to reduce the measurement from two to one for all substances falling under Article 11(6) has been granted.

*In the cement industry several plants do not measure TOC and CO continuously as required by **Article 11(2)**. This is not in line with the WID.*

Exemptions from Emission limit values according to **Annex II.1** (cement industry) have been granted by at least three Member States (LT, UK, CZ)

Exemptions for the monitoring requirements for PCDD/F according to **Article 11(7)** have been reported by two MS. Three Member States out of 15 replies indicated reduction of the monitoring requirements of heavy metals.

No exemptions according to Article 11(7) have been indicated in the cement industry. In the lime sector only Germany has reduced the number of periodic measurements from twice a year to once a year for all substances regulated under 11(7). ***In the UK some lime kilns have been permitted higher ELVs for heavy metals than the ones laid down in Annex II.***

Only one MS of 14 replies reported continuous measurement for heavy metals according to **Article 11(13)**. In the lime industry one plant in the cement sector about 25 plants reported continuous measurements of Hg.

2.6. Summary of the data collection

2.6.1. General aspects of the implementation of the WID

The identification of existing plants to be permitted according to the WID was done via registers of installations or checking of existing installation permits or of emission related permits. In some cases the identification of plants has been realised during routine procedures related to licensing. The minority of Member States has provided information requested according to Article 12(2) of the WID on the access to public information about co-incineration and incineration plants which is a reporting requirement without the possibility to be exempted from.

The way the implementation of the WID provisions by the due dates was done was not described in detail but it was mainly stated that operators had to apply for new permits. In some Member States existing permits have been systematically checked. Regional permitting authorities have been informed about new requirements.

Regarding the answers on small waste oil burners the picture varies from “permitting under the WID” to “not allowed” or “not allowed below certain capacities” and “leaving the decision to the consideration of the regulator”. The WID is applied in three Member States for small waste oil burners and in three Member States waste oil burning is prohibited either generally or below certain capacities. In one Member State the WID is applied on a case to case basis.

Regarding the answers on thermal cleaning of equipment or soil the picture again varies from “permitted under the WID”, “consideration of recovery process classification”, “application of other legislation on these installations” up to not permitted under the WID. In three Member States the WID is not applied for such installations. In two Member States the WID is applied and specific ELV have been elaborated. In one Member State the WID seems to be applied on a case to case basis.

Regarding the use of high calorific waste for expansion of the raw material in ceramic kilns the answers vary from “have to fulfil WID requirements” to “application of other legislation like national emission limits or IPPC permits”. In four Member States the WID is applied to ceramic kilns combusting waste and in one only for paper sludges from recycling of paper waste. In two Member States the use of waste in this process is not seen as co-incineration and the waste is considered to be raw material.

Concerning the question whether emission limit values are valid only during the time when waste is incinerated or all time for the installation as such, the answers range from application of the WID even if no waste is incinerated to application of the WID only if waste is incinerated. In one case the application depended on the frequency of waste co-incineration.

Several problems experienced with the practical implementation of the WID were reported by the stakeholders, mainly referring to definitions and scope, partly to measurement requirements and operating conditions.

Areas of the WID suggested for amendment were the scope, some definitions (the terms incineration, co-incineration, gasification, pyrolysis, plasma processes, abnormal operating conditions) and clarification or amendments have been required regarding emission limit values as well as their determination for specific industry sectors, monitoring requirements, operating conditions and Annex II (see also chapter 4.1 of this report).

Stricter conditions in WID permits have been imposed for efficient energy use, for noise abatement, accident prevention among others. Stricter emission limit values have been set by some Member States, e.g. for air emissions like total dust, CO, HCl, HF, NO_x, SO_2, Hg but also for waste water emissions.

2.6.2. Aspects of the implementation of the WID specific to co-incineration and incineration sector

This chapter merges the summaries of chapter 2.4.11 and2.5.16.

The total number of reported incineration and co-incineration plants adds up to 1444.

Thereof 849 **co-incineration plants**[85] have been reported. Due to the incompleteness of the available data basis 27% of the installations could not be assigned to an industry sector or type of installation. Most of the installations are dedicated waste incinerators (41% of the reported installations). 15% of the installations incinerating or co-incinerating waste are power plants and 10% belong to the cement industry.

Between 566 and 595 **incineration plants** have been reported.

The majority of incineration plants have been indicated for France (155), followed by the UK (85) and Germany (70).The majority of co-incineration plants has been reported by Italy (487). For all plant types the number of existing plants is much higher than the number of new plants.

[85] For the Cement industry the mean of Cembureau's and MS information has been taken into account (143 plants).

The distribution of plant types in the co-incineration and incineration sector is presented below.

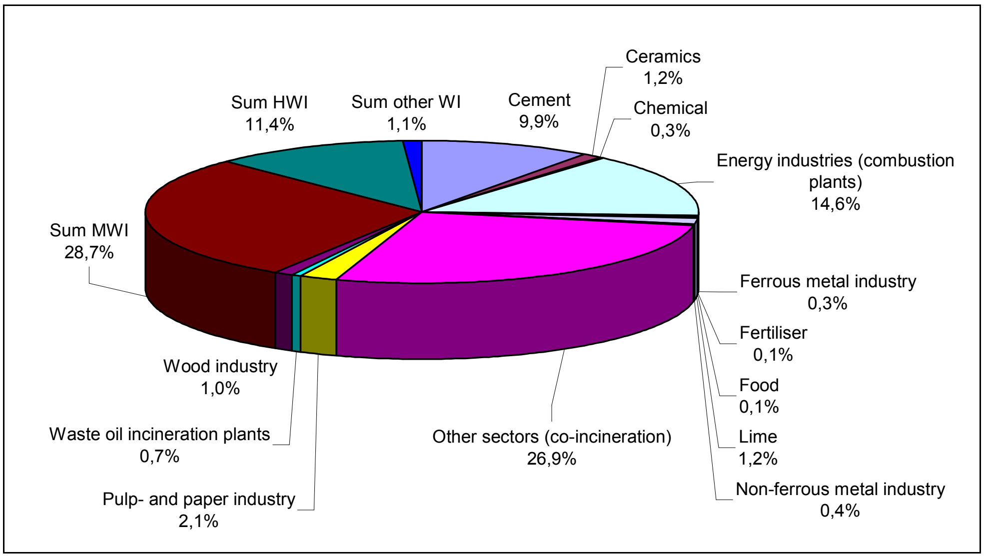

Figure 8: Distribution of (co-)incineration plants per sector as reported

The reported waste input amounts to 60 million tonnes being incinerated in dedicated waste incinerators. Approximately 90% of all waste is incinerated in MWI. Most waste incineration is carried out in France (~ 27%) and Germany (~ 26%).

The total reported waste amount being co-incinerated amount to approximately 13 million tonnes while the cement sector provides half of this figure. Except for the cement and lime sector data uncertainty for the reported data on co-incinerated waste amounts is high or very high.

Exemptions from operating conditions were granted at least for 160 plants. No clear preference could be identified regarding exemptions from residence time or temperature.

Exemptions from measurement requirements have been granted mostly from the continuous measurement in particular of HF, HCl and SO_2.

Table 49: Reported exemptions for the monitoring requirements according to Article 11(6) and 11(7) per sector

Substance	HCl	HF	SO_2	Hg	Cd + Tl	Sum of HM	PCCD/F
Sector							
Cement	112	113	64	0	0	0	0
Chemical/Polymers	1	1	1	0	1	1	0
Energy industries combustion plants)	22	30	12	0	0	0	0
Fertiliser	2	2	0	0	0	0	0
Lime	12	13	11	6	6	5	6
Non-ferrous metal industry	2	2	2	0	2	2	2
Sum MWI	85	228	80	1	1	1	1
Sum HWI	1	26	0	0	0	0	0
Sum not specified incinerators	11	83	10	6	3	6	6
	248	498	180	13	13	15	15

Reduction in measurement frequency has apparently also been permitted in some cases for substances for which have no such clause is included in the WID (see below).

Table 50: Number of exemptions granted being not stipulated by the WID

	Cement	Lime	Precious metal recovery	Waste incinerators
Total dust		indication from 2005 available but not verified	2	3
NOx			2	
TOC	33-83		2	
CO	52-109			
HCL		6	2	3
HF		6	2	5
SO2		5-6	2	3
Cd +Tl		1		2
Sum of Heavy metals				1
Hg				2

Especially in the cement industry those exemptions seem to be quite common. In case of the lime industry those exemption were granted exclusively by Germany.

Air-PAH's are monitored in all plants in the UK, Germany and Italy. For about 90 plants monitoring requirements for PAH were indicated and in particular by the Cement industry. All of those plants measure PAH's periodically while the number of measurement deviated highly.

The monitoring of water PAH's is applicable for all plants in Italy and for all waste incinerator in the UK. The only ELV indicated stems from Italy being 0.0002 mg/l to measured every half year

A number of other air pollutants is monitored in several Member States: CFC, CO_2, HCFC, N_2O, NH_3, SF_6, PCB, Benzo-a-pyren, Benzene, Phenol, Zinc, HCN, Acrolein, CAN, Acetonitril.

A number of other water pollutants is monitored in several Member States: COD, NH_4, TOC, F, AOX, pH, SO_4, Cl, NEL sulfidity.

A number of special provisions have been set out for the water discharges from FGT mostly concerning the measurement frequency. In case of the UK the mixing rule is applied also to waste water.

2.7. Conclusions from the data collection and data gaps of the waste incineration and waste co-incinerations sector

The collection of data about the implementation of the WID highlighted that in most of the Member States no regular information flow is established, that ensures availability of information about the permits for incineration and co-incineration plants at a central point. This touches also the implementation of Article 12(2) of the WID on the access to information about co-incineration and incineration plants which seems to be only followed by the minority of the Member States. The information submission of the EU 15 Member States was rather low regarding this subject. Feedback mechanism about the implementation of the WID in concrete permits to the national responsible institution and centralised information management is often not yet established.

Concerning the approaches used for the implementation of WI Directive together with IPPC Directive only three Member States stated that they use a combined permitting strategy and have implemented both Directives together. No evidence was presented that a common implementation of both directives was not possible.

The number of permits for "existing" plants can be considered as high when taking into account the indicated permitting situation in most Member States. Most plants awaiting permit are situated in one Member State and therefore this does not seem to be a structural problem of the WID. Similar is true for the number of permits for new plants. A lower level of compliance could be observed for a number of measurement exemptions which have been granted although the possibility to have them is not foreseen in the WID. It is assumed that more of such exemptions may exist on the regional level.

The overall level of usage of exemptions is rather low but differs depending on the type of exemption. With approximately 25%[86] of the plants a comparably high number of exemptions have been granted for measurements of SO_2, HCl and HF according to Article 11 (6). Most exemptions were granted in the lime and cement industry and for dedicated waste incineration plants. At least 13% of the plants have been granted exemptions from certain operating conditions. A very low number of exemptions have been indicated for heavy metals and dioxins according to Article 11(7) and from ELVs (Annex II).

Regarding information on the amount of waste used in the co-incineration plants improved information flows in the Member States are seen as helpful in order to improve comprehensibility of the overall picture.

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86 Some double counting could not be avoided as some plant measure periodically and continuously

3. Cost-benefit analysis – case studies

3.1. Introduction

This section aims at providing a picture of the costs and benefits from the implementation of the WID. The analysis was performed for 15 case studies which have been chosen in a multi criteria approach in order to cover relevant industry sectors incinerating or co-incinerating waste (present situation as well as the future perspective). The selection of cases also took up the result of an analysis about the permits issued for the plants (WID, IPPC) in order to be able to take into account possible effects of this specific regulatory background. Finally the size of the installations[87] was considered in order to cover the most relevant ranges of installation sizes. The following table (overleaf) summarises the results of the analysis and shows in the last column the selected cases regarding size and regional distribution

Baseline of the analysis is the situation of the individual plant before the WID has been applied. In most cases emission related requirements and air emissions have been in the focus as most relevant impacts. Effects on energy production (e.g. from new boilers) or energy efficiency of the installation have not been considered.

Cost savings for operators resulting from the substitution of fuels by waste have been estimated where basic data on the total amount of waste incinerated was made available.

[87] It is not seen as relevant for example when only large installations exist as it is for example the case in the European steel industry.

Table 51: Type of installations and criteria for selection of plants for an assessment of costs and benefit of WID compliance

Type of installation	Type of installation generally covered by IPPC?	Countries that have this type of WID installations[2]	Installation size of high relevance for appraisal of costs	Present mass relevance for waste incineration/ co-incineration	Assumed future mass relevance of waste incineration/ co-incineration	Installations included in the CBA
Dedicated Municipal Waste Incineration	Y[1]	Several	Y	High	Declining	1 large plant in HU, 1 small in CZ or FR
Dedicated Hazardous Waste Incineration	Y[1]	Several	Y	High	Declining	1 large plant in BE, 1 small plant in CZ
Cement Industry	Y[1]	Several	[3]	High	Increasing	2 large plants, 1 small, focus on De-NOx techniques and dust removal
Large Combustion Plants	Y[1]	Several	Y	Average	Increasing	1 plant in IT or DE, 1 in New Member States
Lime Industry	Y[1]	DE, FR, FI, DK, SE, UK	Y	Average	Declining	1 plant in EU 15
Ceramic Industry	Y	EE, ,SE, ES, DK, FI, IT, PL	Y	Low	N/A	1 plant in DK, proposed by EXCA
Secondary Steel Industry	Y[1]	AU, LU	[3]	Low	N/A	Luxembourg plant

[1] most (co-)incinerated waste is used in IPPC installations
[2] basis: stakeholder questionnaire
[3] only large plants are co-incinerating waste
[4] only small plants (co-)incinerate waste

The data basis for the cost-benefit analysis was elaborated via personal contact with plant operators, additional support of industry associations, expert interviews and literature research.

For the calculation of health and environmental impacts and damage costs related to ambient emissions from the risk assessment program RiskPoll has been applied. Quantification of the impacts and damage costs follows the impact pathway methodology developed by the ExternE Project of the European Commission[88]. In addition to health effects, RiskPoll also computes impacts and damage costs to agricultural crops, building materials, and impacts to public health due to ionizing radiation (the latter based on the work by the UN Scientific Committee on the Effects of Atomic Radiation.” [Spadaro 2007][89] ;

In this chapter not all possible calculation were carried out since not all substances could be calculated with Risk Poll. Regarding heavy metals mean values of European emissions have been applied. For the Dust (PM10) and secondary particles like sulfates and nitrates site specific values were generated. The calculated benefits from TOC reductions take only non methane volatile organic compounds (NMVOC) into account. All values in EURO refer to the value of a Euro of the base year 2000 ($€_{2000}$).

[88] [ExternE 2005] Externalities of Energy: Methodology of 2005 update. Published by European Commission, Directorate General for Reasearch, Sustainable Energy Systems

[89] Joseph V. Spadaro: Cost of environmental pollution, Centre énergetique et procédes (CEP), Armines/Ecole de Mines de Paris, Paris, France, to be published in 2007

3.2. Dedicated Municipal Waste Incinerator in Budapest (Hungary)

3.2.1. Description of the plant

The Dedicated Waste Incineration plant in Budapest/Hungary started its operation in 1981. The plant was upgraded in 2005 (new boilers and new waste gas abatement) to comply with the requirements of the Waste Incineration Directive.

The installation is owned by Municipal Public Services Co. Ltd. (Fővárosi Közterület Fenntartó Rt.). It is the only waste incinerator in Hungary, with a capacity of treating 420,000 tonnes of municipal solid waste per year. In 2006 about 400,000 tonnes was incinerated (approx. 65-70 % of the waste generated in Budapest).[90] [Bánhidy 2007]

The plant belongs to the group of very few large Dedicated Waste Incineration plants that existed in the 10 New Member States when the Waste Incineration Directive was implemented. Its former as well as its actual capacity is similar to the largest Dedicated Waste Incineration plants in EU 15.

The following table compares the major parameters of the plant before and after upgrading.

Table 52: Major parameters of the Dedicated Waste Incinerator in Budapest before and after upgrading

Parameter	before 2005	after 2005
Max. capacity	360.000 tonnes per year	420 000 tonnes per year
Number of lines	4	
Type of technology	moving grate	
Type of waste input	municipal solid waste, non pretreated	
Max. waste input	15 t/h each line, total: 60 t/h	
Max. steam production	40 t/h each line, total: 160 t/h	
Steam parameters	40 bar, 400°C	40 bar, 405°C
Boiler efficiency	73 %	82 %
Stack height	120 m	120 m
Turbine generator capacity	24 MW	24 MW
Energy production	1 898 604 GJ/yr	2 557 675 GJ/yr
Export of energy Electricity Heat	773 433 GJ/yr 340 410 GJ_e/yr 433 023 GJ_{th}/yr	981 859 GJ/yr 494 412 GJ_e/yr 487 447 GJ_{th}/yr
Flue-gas treatment	Electrostatic precipitator (ESP)	SNCR (with urea), semi-dry cyclone absorber with lime milk injection, active lignite coke injection, fabric filters
Solid residues for disposal	slag and fly ash together	separation of slag, fly ash, flue gas treatment residues

[Bánhidy 2007]

90 see http://www.fkf.hu/angol.html

3.2.2. Costs and benefits

The following tables show the trend of emission values and the decrease of pollutants of the municipal waste incinerator in Budapest of the municipal waste incinerator in Budapest before and after upgrading.

Table 53: Development of emission values of the municipal waste incinerator in Budapest

Parameter	before 2005 *		after 2005	
Temperature of treated flue-gas Volume of treated flue-gas	260 °C 320 000 m^3/h (80 000 m^3/h each line)		140 °C 320 000 m^3/h (80 000 m^3/h each line)	
Annual average emissions into air, continuous monitoring [mg/m^3]	range	mean	mean	
Dust	40-120	91	0.47	
VOC as TOC	1-4	2	0.50	
HCl	400-500	489	4.38	
HF	1-4	2	0.61	
SO_2	80-120	110	13.43	
NO_x as NO_2	260-320	296	164.31	
CO	20-45	37	19.85	
NH_3	-	-	4.79	
Emissions into air, periodic monitoring, [mg/m^3]	range	mean	range	mean
Hg [mg/m^3]	0.02-0.5	0.137	0.001-0.005	0.0033
Cd and Tl [mg/m^3]	0.02-0.1	0.025	<0.005	0.00356
Σ other metals [mg/m^3]	2-8	3.5	0.05-0.117	0.077
PCDD/F [ng TEQ/m^3]	0.5-1.2	0.9	0.0002-0.0105	0.0030
Solid residues for disposal	slag and fly ash together		separation of slag/fly ash/FGT residues	
* Before reconstruction the following parameters were measured continuously: Dust, HCl, SO_2, CO.				

[Bánhidy 2007]

Table 54: Decrease of pollutants of the municipal waste incinerator in Budapest

Emissions	Decrease of annual emissions into air after reconstruction	
Continuous measurement	(for 350 days/year of operation with 320,000 Nm^3/h)	
Dust	243 tonnes	99 %
VOC as TOC	4.0 tonnes	75 %
HCl	1303 tonnes	99 %
HF	3.7 tonnes	70 %
SO_2	260 tonnes	88 %
NO_x as NO_2	354 tonnes	44 %
CO	46 tonnes	46 %
Periodic measurement		
Hg	359 kg	97.4 %
Cd and Tl	58 kg	86.8 %
Σ other metals	9201 kg	97.8 %
PCDD/F [TEQ]	2.4 g	99.7 %

[Bánhidy 2007]

The total investment costs for refurbishment of the 4 boilers and the new waste gas cleaning system was about 60 m Euros. About 24 m Euro of the total costs can be assigned to the new boilers with efficient energy recuperation, 36 m Euro are assigned to the new flue gas cleaning system (including monitoring) and the residue treatment. [Bánhidy 2007]

The investment per year for a 10 years depreciation period is about 4.0 m Euro, including an assumptive interest rate of 10%. The resulting specific costs is about 9.5 €/tonne waste.

The operational costs due to the waste gas cleaning are as follows:

- 1.04 m Euro for electricity (including induced draft fan),
- 0.48 m Euro for additives,
- 2.60 m Euro for residue management,
- 0.06 m Euro for monitoring,
- 0.12 m Euro for personnel. [Bánhidy 2007]

The operational costs per year account for about 4.3 m Euro or 10.8 Euro per tonne of waste. It is assumed that the costs of waste gas treatment (for an installation with 60,000 tonnes less capacity) were as following before upgrading:

- about 60% = 0.62 m Euro for electricity,
- 0 Euro for additives,
- about 10% = 0.26 m Euro for residue management,
- about 20% = 0.001 m Euro for monitoring, and
- about 50% = 0.06 m Euro for personal. [Bánhidy 2007]

This results in total costs of about 0.94 m Euro per year.

The additional costs only related to the new waste gas abatement system consists of yearly investment costs of about 4.0 m Euros and additional operational costs of about 3.4 m Euros, adding up to 7.4 m Euros. This results in specific costs of the new waste gas treatment of about 18.5 Euros per tonne of waste.

The approximate reduction of health and environmental related damage costs based on RiskPoll calculations amounts to ~ 7 m Euro annually. The following table shows details of the calculation.

Table 55: Monetised damage costs and health & environmental benefits based on the RiskPoll-Model

Substance	MDC in $€_{2000}$ per kg emission	Decrease of annual emissions into air [in kg]	Monetised benefits in $€_{2000}$
PM10	15	243,000	3,645,511
SO2	4.9	260,000	1,262447
NOx	4.3	354.000	1,505907
Cd	39	58	2,262
Hg	1400	359	502,600
Dioxins	250,000,000	0.0024	600,000
NMVOC	1.124	4000	4,496
Sum			7,525,224

3.3. Dedicated Municipal Waste Incinerator in Antibes (France)

3.3.1. Description of the plant

The dedicated municipal waste incinerator in Antibes is operated by Syndicat Mixte de Traitement des Ordures Ménagères (SIDOM). It was constructed in 1970 with a capacity of 19 tonnes per hour (about 160,000 tonnes per year). Currently it is upgraded with a boiler for electricity production.

The waste gas treatment installed in 1988 consists of a carbonate injection in semi-dry scrubber for acid gases followed by a bag house filter.

The new elements of the waste gas abatement, installed in 2007, consist of an injection of activated carbon and a SCR installation for NOx abatement. The new monitoring equipment consists of a continuous sampling of PCDD/F (before: periodically measured twice a year). [SIDOM 2007]

3.3.2. Costs and benefits

Table 5 shows the emissions of the dedicated waste incinerator in Antibes before and after upgrading

Table 56: Emissions of Dedicated Waste Incinerator in Antibes/France

	Specific emission values before upgrading	Emission concentration before upgrading	Emission concentration after upgrading	Emission reduction	
Total dust	1,890 kg/y	2.21 mg/Nm³	2.21 mg/Nm³		
NOx	272,270 kg/y	331.1 mg/Nm³	80.0 mg/Nm³	76%	~ 206.5 t/y
CO	16,740 kg/y	20.23 mg/Nm³	20.23 mg/Nm³		
SO_2	980 kg/y	1.2 mg/Nm³	1.2 mg/Nm³		
TOC	780 kg/y	0.96 mg/Nm³	0.96 mg/Nm³		
HCl	3,580 kg/y	4.3 mg/Nm³	4.3 mg/Nm³		
HF	40 kg/y	0.04 mg/Nm³	0.04 mg/Nm³		
PCDD/F	87.5 mg/y	0.105 ng/Nm³	0.05 ng/Nm³	52 %	~ 45,8 mg/y
at normal conditions (101,32 kPa, 0°C), 11% O_2					

[SIDOM 2007]

The upgrading for compliance with the Waste Incineration Directive implied a total investment of about 20 m Euros [SIDOM 2007].

Assuming a depreciation of 10 years and capital costs of 10 % per year, the total investment costs are about 3 m Euro per year. Expected operating costs have not been reported.

The approximate reduction of health and environmental related damage costs based on RiskPoll calculations amounts to 11,250 €/y for PCDD/F reduction and 254,480 €/y, adding up with 265,730 €/y while NOx reduction presents the major benefit with 98% of the total.

3.4. Dedicated Hazardous Waste Incinerator ZENTIVA in Prague (Czech Republic)

3.4.1. Description of the plant

The Dedicated Hazardous Waste Incinerator of Zentiva group (a pharmaceuticals producer) started its operation in 1993 in Prague.

Hazardous waste input consists of liquid waste not allowed to be cleaned in the sewerage plant, solid waste of the pharmaceutical and chemical production, used absorbents, filters and non-suitable products.

The waste incinerator has a capacity of 0.4 tonnes per hour, consisting of 3 ovens: A muffle oven for the incineration of fluidised waste, a continuously operated rotating oven for the incineration of solid waste and de-watered sludge from the sewerage plant, and a pyrolysis oven with subsequent incineration for the incineration of crushed and not-crushed solid waste (discontinuously operating).

Since 1994 the incinerator was operated with two stages of waste gas cleaning (wet scrubber and fabric filter). In 2003 the plant was upgraded with a third cleaning stage for mercury and PCDD/F abatement via injection of activated lignite coke. A continuous measurement of emissions was installed in 2004. [Zentiva 2007]

3.4.2. Costs and benefits

Table 57 shows the comparison of emission limits and performance of the hazardous waste incinerator of Zentiva before and after upgrading in 2003.

Table 57: Development of emission limits and monitoring results of the hazardous waste incinerator of Zentiva in Prague

<table>
<tr><th>Parameter</th><th>limit until 31.5.02</th><th>limit from 1.6.02</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th></tr>
<tr><td>Dust [mg/m^3]</td><td>30</td><td>10</td><td>24,6</td><td>1,5</td><td>5,2</td><td>4,1</td><td>1,1</td><td>0,7</td><td>0,4</td></tr>
<tr><td>SO_2 [mg/m^3]</td><td>300</td><td>50</td><td>20</td><td>19</td><td>10</td><td>9</td><td>35</td><td>10</td><td>2</td></tr>
<tr><td>NOx (as NO_2) [mg/m^3]</td><td>500</td><td>400</td><td>140</td><td>126</td><td>210</td><td>133</td><td>212</td><td>176</td><td>167</td></tr>
<tr><td>CO [mg/m^3]</td><td>100</td><td>50</td><td>5</td><td>12</td><td>9</td><td>27</td><td>11</td><td>5</td><td>1,7</td></tr>
<tr><td>TOC [mg/m^3]</td><td>20</td><td>10</td><td>3,1</td><td>4,4</td><td>5,3</td><td>4,1</td><td>2,6</td><td>2,0</td><td>3,1</td></tr>
<tr><td>HCl [mg/m^3]</td><td>30</td><td>10</td><td>0,31</td><td>0,4</td><td>2,3</td><td>0,285</td><td>1,73</td><td>0,09</td><td>< 1,4</td></tr>
<tr><td>HF [mg/m^3]</td><td>2</td><td>1</td><td>0,03</td><td>0,02</td><td>0,06</td><td>0,09</td><td><0,1</td><td>0,07</td><td>0,1</td></tr>
<tr><td>Hg [mg/m^3]</td><td rowspan="2">0,2</td><td>0,05</td><td rowspan="2">0,01</td><td rowspan="2">0,003</td><td>0,017</td><td>0,002</td><td>0,009</td><td>0,005</td><td>0,0005</td></tr>
<tr><td>Cd + Tl [mg/m^3]</td><td>0,05</td><td>0,042</td><td>0,009</td><td>0,05</td><td>0,006</td><td>< 0,005</td></tr>
<tr><td>Sum of As, Ni, Cr, Co [mg/m^3]</td><td>2</td><td rowspan="2">0,5</td><td>0,011</td><td>0,011</td><td rowspan="2">0,161</td><td rowspan="2">0,022</td><td rowspan="2">0,018</td><td rowspan="2">0,043</td><td rowspan="2">0,01</td></tr>
<tr><td>Sum of slug, copper and manganese [mg/m^3]</td><td>5</td><td>0,334</td><td>0,015</td></tr>
<tr><td>PCDD/F [ng/m^3]</td><td></td><td>0,1</td><td></td><td>1,92</td><td>4,2</td><td>0,015</td><td>0,004
0,060</td><td>0,010
0,061</td><td>0,017
0,011</td></tr>
<tr><td colspan="3">Gas volume at normal conditions (101,32 kPa, 0°C) and 11% O_2 [m^3/h]</td><td>11.050</td><td>10.290</td><td>9.010</td><td>5.010</td><td>5.110</td><td>5.115</td><td>4.000</td></tr>
<tr><td colspan="10">Marked in green: emission reduction after installation of coke injection</td></tr>
</table>

[Zentiva 2007]

The investment costs for the third stage of waste gas cleaning (adsorption with activated coke) was 424,500 Euro (12 m CZK). [Zentiva 2007]

Assuming a depreciation of 10 years and capital costs of 10 % per year, the total investment costs are about 63,675 Euro per year.

The operating costs are about 17,700 Euro (0.5 m CZK) per year. [Zentiva 2007] resulting from the use of additives and additional power consumption.

Based on these figures, total costs result in about 81,400 Euros per year or ~25 Euro per tonne of waste.

Before reconstruction in 2002 the emission of PCDD/F was 20 - 38 µg per hour (166 - 318 mg PCDD/F emissions per year if continuously operated during 350 days).

After reconstruction in 2003 the emission decreased to a level of 0.02 – 0.31 µg per hour equivalent to a decrease by factor 1000 (if the plant is continuously operated during 350 days a year, the resulting PCDD/F emissions is between 0.2 – 3.2 mg per year).

The savings are restricted to effects of PCDD/F emission reduction and amount to 60000 Euro in health and environmental benefits based on RiskPoll.

3.5. Dedicated Hazardous Waste Incinerator T.O.P. EKO in Plzen (Czech Republic)

3.5.1. Description of the plant

The hazardous waste incinerator in Plzen is operating since 1994. The incinerator is co-owned by the city of Plzen (prior owner and operator) and the company T.O.P. EKO, (actual operator).[91]

The incinerating facility is built up with a two stage pyrolysis (NORSK HYDRO type NH 2300 SG-C) providing of automatic dispensing of waste and operating at temperatures between 750 and 1000°C.[92] The capacity of the incinerator is about 240 - 320 kg per hour, operating during 24 hours. The incinerator provides of an own sewage plant for waste water.

The waste gas cleaning consists of a first stage of dry adsorption. The second stage consists of an active coke injection. The two stages are followed by a bag house filter. The third stage is a wet scrubber combined with a multi-venture pipe.

The upgrading of the incinerator was realised in two periods in 2003 and 2005. In the first period in 2003 the existing wet scrubber was completed with the stages of adsorbent injection. The upgrading implied changes of pressure in the waste gas abatement system resulting in a reduction of the capacity of about 20%.

In the second period of upgrading, the incinerator was equipped with a continuous emission monitoring system in 2005. [TOP ECO 2007]

3.5.2. Costs and benefits

The following table shows the development of emission limits and the monitoring results of the hazardous waste incinerator of T.O.P. EKO in Plzen.

91 see also http://www.spalovnaplzen.cz

92 Information provided by TOP ECO. Waste Incineration Directive requires a minimum temperature of 850°C for two seconds. If hazardous waste with a content of more than 1% of halogenated substances is incinerated, 1100°C for at least two seconds is required. Different conditions may be may be authorised by the competent authority, provided the requirements of this Directive are met. (Article 6)

Table 58: Development of emission limits and monitoring results of T.O.P. EKO hazardous waste incinerator in Plzen

Emissions (all [mg/m³] but PCDD [ng/m³])			
	limit value	**before reconstruction**	**after reconstruction**
Total dust	10 (20)	9 – 15	0.8 – 1.5
CO	50	9 – 28	4
NOx	400	100 - 134	108
TOC	10	5 - 6	1.9
SO_2	50	10 - 40	10 - 26
HCl	10	1 - 8	1 - 8
HF	1	0.1 – 0.6	0.1 – 0.6
Heavy metals			-50%
PCDD/F	0,1	0.3 – 1.5	0.02 – 0.09
	Gas volume [m³/h]	4,400	
		Marked in green: major reductions	

[TOP ECO 2007]

Absolute data about the emission of heavy metals instead of the relative value (-50%) have not been provided.

The total investment for the coke injection stage was about 160,630 Euro. The investment of the monitoring system was 63,122 Euro, resulting in total investment costs for the third stage of the waste gas control system of about 223,750 Euros per year. [TOP ECO 2007]

Assuming a depreciation of 10 years and capital costs of 10 % per year total costs from investments are about 33,600 Euro per year.

Additional operating costs of the third stage cleaning system result from the injection of activated coke and from increased electricity consumption. Operational costs have not been provided.

The total amount of PCDD/F emissions before reconstruction was 10.1-51.5 mg/y. After reconstruction, PCDD/F emissions decreased to a level between 0.7 and 3.1 mg/y (factor 14-17 if operated 7800 hours per year). The savings are restricted to effects of PCDD/F emission reduction and amount to 7250 Euro in health and environmental benefits based on RiskPoll.

3.6. Dedicated Hazardous and Non-Hazardous Waste Incinerators of INDAVER (Belgium)

3.6.1. Description of the plants

The Indaver group treats in Belgium non hazardous waste in three grate furnaces in Beveren near Antwerp and hazardous waste in two rotary kilns and one static kiln in Antwerp (they also operate one new fluidized bed kiln, which is not considered here).

For the hazardous waste incinerators, the flue gases are de-dusted in an electrostatic precipitator and in a four-step gas-cleaning process. A fixed bed lignite coke filter is used to remove dioxins and any other substances like mercury. Urea is used in a SNCR system for NOx abatement in all furnaces. [INDAVER web 2007]

In the grate incinerators, Indaver treats non-hazardous municipal waste, similar industrial waste, and some specific waste materials, such as non-hazardous medical waste and sewage sludge.

Waste gas is cleaned with SNCR for NOx reduction (operated with urea), a semi-dry scrubber stage, a wet scrubber stage as well as an activated carbon injection and a bag house filter. [INDAVER web 2007]

With the implementation of the WID an emission limit value of 200 mg/Nm^3 and mandatory continuous measurement of NOx was required for the plants. On this background the SNCR systems had been installed.

3.6.2. Costs and benefits

The table below shows the results of the NOx emission monitoring for 2004 and 2005.

Table 59: NOx emissions of hazardous waste incinerators of Indaver in Belgium

	2004 [mg/Nm^3]	**2005** [mg/Nm^3]	**until sept/2006** [mg/Nm^3]	**reduction in 2006 compared to 2005**
Rotary kilns	255	292	< 150	51 %
Grate furnaces	299	282	132	47 %
Limit value NOx	400	400	200	

[INDAVER 2007]

The emission of NOx was reduced by ~50% by the De-NOx installations. In 2005, the yearly gas volume was 652,475,000 Nm^3 for the rotary kilns and 2,215,260,000 Nm^3 for the grate furnaces. Assuming that the NOx emission level was decreased by about 145 mg/m^3 in both types of waste incinerators, a total NOx reduction of about 416 tonnes per year has been achieved.

The investment and operational costs for the improvement of the NOx air emission by the De-NOx installation on the rotary kiln and the grate furnace are given in following table.

Table 60: Investment and operational costs for NOx abatement at hazardous waste incinerators of Indaver in Belgium

Installation	Investment cost	Operational cost (€/year)	Amount of waste (ton/year)	Operational costs (€/tonne waste)
2 rotary kilns	500,000 €	156,572 €	104,381	1.50 €
3 grate furnaces	500,000 €	290,956 €	363,695	0.80 €

[INDAVER 2007]

Assuming a depreciation of 10 years and capital costs of 10 % per year, the total investment costs for the rotary kilns as well as for the grate furnaces are about 75,000 Euro per year each.

Based on this, investment costs and operational costs result in about 232,000 Euro per year for the rotary kilns (~2.22 € per tonne of waste) and in about 366,000 Euro per year for the grate furnaces (~1.01 € per tonne of waste).

Based on RiskPoll calculation, environmental and health benefits of 416 tonnes of NOx emission reduction sum up with 2.5 m Euros.

3.7. Waste co-incineration in a medium size cement plant with medium initial NOx level (Germany)

3.7.1. Description of the plant

As individual plant data has not been provided by the cement industry, the following example is based on average data of several plants [Germany 2006].

The data is presented for an exemplary cement plant with a capacity of 1500 tonnes of clinker production per day (around 480,000 tonnes per year), operating at 320 days a year (7,680 h/y).

The example plant has an initial NOx level of 1,000 mg/m^3 (2.3 kg per tonne of clinker), and the waste gas volume is 143,750 m^3/h (2,300 m^3 per tonne of clinker), resulting in daily NOx emissions of 3.45 tonnes (1,104 tonnes per year).

SNCR technique was installed for NOx reduction to achieve NOx emissions of 500 mg/m^3.

The plant produces with a thermal efficiency of 3000 MJ per tonne of clinker, requiring about 50,000 tonnes of coal per year (29 MJ/kg) for full capacity production without co-incineration. Waste co-incineration contributes 60 % of heat release to the process. For this purpose, about 58,000 tonnes of waste (15 MJ/kg) are co-incinerated substituting about 30.000 tonnes of coal.

3.7.2. Costs and benefits

With SNCR technique, NOx emissions of an initial level of 1,000 mg/m^3 is reduced 50% to an emission level of 500 mg/m^3, resulting in 1.73 tonnes of NOx reduction per day (552 tonnes per year), thus 1.15 kg NOx reduction per tonne of clinker.

NOx is destroyed in an oxidizing atmosphere be a two step process that can be summarized as: $4\ NH_3 + 4\ NO + O_2 \rightarrow 4\ N_2 + 6\ H_2O$ (molar NH_3/NO ratio is 17/30 = 0.56). 1.15 kg NOx reduction is expressed as NO_2, but NOx in the system consists mainly of NO (molar ratio of NO/NO_2 is 30/46 = 0.65), thus 1.15 kg NOx (as NO_2) is equivalent to 0.75 kg NO.

For the reduction of 0.75 kg NO per tonne of clinker, in a stoichiometric reaction 0.425 kg ammonia per tonne of clinker is needed. Due to kinetics, in reality a stoichiometric factor of 1.7 is needed to achieve a 50% NOx reduction [Schäfer/Hoenig 2006]. Based on this, for 0.75 kg NO reduction an injection of 0.7225 kg ammonia per tonne of clinker is needed.

Ammonia is used as 25% dilution, thus 2.89 kg ammonia water per tonne of clinker is injected, summing up to 4,335 kg of ammonia water per day (1,387 tonnes per year). Ammonia water (25%) is calculated with a price of 90 Euros per ton, resulting in ammonia water costs of 390 Euros per day and 124,848 Euros per year (0.26 Euro per tonne of clinker).

Electricity costs for the SNCR system is assumed with 45 Euros per day, resulting in annual electricity costs of 14,400 Euros (0.03 Euro per tonne of clinker).

Investment costs for the SNCR system are calculated with 600,000 Euros[93]. Assuming a depreciation of 20 years and capital costs of 10%, annual investment costs result in 60,000 Euros (0.12 Euro per tonne of clinker).

Annual investment and operational costs sum up with 199,248 Euros. This is equivalent to 0.42 Euro per tonne of clinker and 361 Euros per tonne of NOx reduction.

Assuming a coal price of 40 Euro per ton and waste revenue of 30 Euro per ton, cost savings from fuel switch are about 2.9 Million Euros per year (6 Euro per ton of clinker).

Based on RiskPoll calculation, environmental and health benefits of 552 tonnes of NOx emission reduction sum up with 2.3 m Euros.

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[93] Investment costs for SNCR NOx abatement systems vary significantly according to local authority requirements for safety measures of ammonia storage (covering about 50% of SNCR investment costs).

3.8. Waste co-incineration in a medium size cement plant with high initial NOx level (Germany)

3.8.1. Description of the plant

The following example is also based on average data of several plants [Germany 2006]. The data is also presented for an exemplary cement plant with a capacity of 1500 tonnes of clinker production per day (around 480,000 tonnes per year), operating at 320 days a year (7,680 h/y).

In contrast to the example plant described before, this example plant has a high initial NOx level of 1,500 mg/m^3 (3.45 kg per tonne of clinker), and the waste gas volume is 143,750 m^3/h (2,300 m^3 per tonne of clinker), resulting in daily NOx emissions of 5.2 tonnes (1,656 tonnes per year).

SNCR technique was installed for NOx reduction to achieve NOx emissions of 500 mg/m^3.

The plant produces with a thermal efficiency of 3000 MJ per tonne of clinker, requiring about 50,000 tonnes of coal per year (29 MJ/kg) for full capacity production without co-incineration. Waste co-incineration contributes 60 % of heat release to the process. For this purpose, about 58,000 tonnes of waste (15 MJ/kg) are co-incinerated substituting about 30.000 tonnes of coal.

3.8.2. Costs and benefits

With SNCR technique, NOx emissions of an initial level of 1,500 mg/m^3 is reduced 67% to an emission level of 500 mg/m^3, resulting in 3.5 tonnes of NOx reduction per day (1,110 tonnes per year), thus 2.3 kg NOx reduction per tonne of clinker.

NOx is destroyed in an oxidizing atmosphere be a two step process that can be summarized as: $4\ NH_3 + 4\ NO + O_2 \rightarrow 4\ N_2 + 6\ H_2O$ (molar NH_3/NO ratio is 17/30 = 0.56). 2.3 kg NOx reduction is expressed as NO_2, but NOx in the system consists mainly of NO (molar ratio of NO/NO_2 is 30/46 = 0.65), thus 2.3 kg NOx (as NO_2) is equivalent to 1.5 kg NO.

For the reduction of 1.5 kg NO per tonne of clinker, in a stoichiometric reaction 0.84 kg ammonia per tonne of clinker is needed. Due to kinetics, in reality a stoichiometric factor of 1.9 is needed to achieve a 67% NOx reduction [Schäfer/Hoenig 2006]. Based on this, for 1.5 kg NO reduction per tonne of clinker an injection of 1.6 kg ammonia per tonne of clinker is needed.

Ammonia is used as 25% dilution, thus 6.4 kg ammonia water per tonne of clinker is injected, summing up to 9,600 kg of ammonia water per day (3,072 tonnes per year). Ammonia water (25%) is calculated with a price of 90 Euros per ton, resulting in ammonia water costs of 864 Euros per day and 276,480 Euros per year (0.58 Euro per tonne of clinker).

Electricity costs for the SNCR system is assumed with 90 Euros per day, resulting in annual electricity costs of 28,800 Euros (0.06 Euro per tonne of clinker).

Investment costs for the SNCR system are calculated with 600,000 Euros[94]. Assuming a depreciation of 20 years and capital costs of 10%, annual investment costs result in 60,000 Euros (0.12 Euro per tonne of clinker).

Annual investment and operational costs sum up with 365,280 Euros. This is equivalent to 0.76 Euro per tonne of clinker and 329 Euros per tonne of NOx reduction.

Assuming a coal price of 40 Euro per ton and waste revenue of 30 Euro per ton, cost savings from fuel switch are about 2.9 Million Euros per year (6 Euro per ton of clinker).

Based on RiskPoll calculation, environmental and health benefits of 1,110 tonnes of NOx emission reduction sum up with 5.0 m Euros.

3.9. Waste co-incineration in a large size cement plant with medium initial NOx level (Germany)

3.9.1. Description of the plant

The following example is calculated for a cement plant with a capacity of 3000 tonnes of clinker production per day (around 960,000 tonnes per year), operating at 320 days a year (7,680 h/y).

The example plant has a medium initial NOx level of 1,500 mg/m^3 (3.45 kg per tonne of clinker), and the waste gas volume is 287,500 m^3/h (2,300 m^3 per tonne of clinker), resulting in daily NOx emissions of 10.4 tonnes (3,312 tonnes per year).

SNCR technique was installed for 50% NOx reduction achieving NOx emissions of 750 mg/m^3.

The plant produces with a thermal efficiency of 3000 MJ per tonne of clinker, requiring about 100,000 tonnes of coal per year (29 MJ/kg) for full capacity production without co-incineration. Waste co-incineration contributes 60 % of heat release to the process. For this purpose, about 116,000 tonnes of waste (15 MJ/kg) are co-incinerated substituting about 60.000 tonnes of coal.

[94] Investment costs for SNCR NOx abatement systems vary significantly according to local authority requirements for safety measures of ammonia storage (covering about 50% of SNCR investment costs).

3.9.2. Costs and benefits

With SNCR technique, NOx emissions of an initial level of 1,500 mg/m^3 is reduced 50% to an emission level of 750 mg/m^3, resulting in 5.2 tonnes of NOx reduction per day (1,664 tonnes per year), thus 1.7 kg NOx reduction per tonne of clinker.

NOx is destroyed in an oxidizing atmosphere be a two step process that can be summarized as: $4\ NH_3 + 4\ NO + O_2 \rightarrow 4\ N_2 + 6\ H_2O$ (molar NH_3/NO ratio is 17/30 = 0.56). 1.7 kg NOx reduction is expressed as NO_2, but NOx in the system consists mainly of NO (molar ratio of NO/NO_2 is 30/46 = 0.65), thus 1.7 kg NOx (as NO_2) is equivalent to 1.1 kg NO.

For the reduction of 1.1 kg NO per tonne of clinker, in a stoichiometric reaction 0.62 kg ammonia per tonne of clinker is needed. Due to kinetics, in reality a stoichiometric factor of 1.6 is needed to achieve a 50% NOx reduction [Schäfer/Hoenig 2006]. Based on this, for 1.1 kg NO reduction per tonne of clinker an injection of 1.0 kg ammonia per tonne of clinker is needed.

Ammonia is used as 25% dilution, thus 4.0 kg ammonia water per tonne of clinker is injected, summing up to 12.0 tonnes of ammonia water per day (3,840 tonnes per year). Ammonia water (25%) is calculated with a price of 90 Euros per ton, resulting in ammonia water costs of 1,080 Euros per day and 345,600 Euros per year (0.36 Euro per tonne of clinker).

Electricity costs for the SNCR system is assumed with 125 Euros per day, resulting in annual electricity costs of 40,000 Euros (0.04 Euro per tonne of clinker).

Investment costs for the SNCR system are calculated with 850,000 Euros[95]. Assuming a depreciation of 20 years and capital costs of 10%, annual investment costs result in 85,000 Euros (0.09 Euro per tonne of clinker).

Annual investment and operational costs sum up with 470,600 Euros. This is equivalent to 0.49 Euro per tonne of clinker and 283 Euros per tonne of NOx reduction.

Assuming a coal price of 40 Euro per ton and waste revenue of 30 Euro per ton, cost savings from fuel switch are about 5.8 Million Euros per year (6 Euro per ton of clinker).

Based on RiskPoll calculation, environmental and health benefits of 1,664 tonnes of NOx emission reduction sum up with 2.3 m Euros.

95 Investment costs for SNCR NOx abatement systems vary significantly according to local authority requirements for safety measures of ammonia storage (covering about 50% of SNCR investment costs).

3.10. Waste co-incineration in a large size cement plant with medium initial NOx level (Sweden)

3.10.1. Description of the plant

The following example is based on data of Slite plant of Heidelberg Cement in Sweden [Junker/Lyberg 2006]. The plant has two ovens with capacities of 1200 and 5800 tonnes per day (max. 2,272,000 tonnes per year if operating on 320 days). Among others, waste oil is used as a fuel.

Both ovens are equipped with SNCR technique since 1998/1999. The technique was installed to achieve NOx emissions of about 200 mg/m^3.

The initial NOx level varies between 800 - 1,100 mg/m^3. Since 1999, yearly average NOx emission values are below 260 mg/m^3. The average NOx reduction is 80%. The specific NOx emission is 0.5 - 0.6 kg per tonne of clinker.

3.10.2. Costs and benefits

The annual NOx reduction and the waste gas volume depend on the clinker production. Assuming a production of 6,200 tonnes per day during 300 days (1,860,000 tonnes per year), the waste gas volume is about 630,000 m^3/h.

Assuming an emission level of 250 mg/m^3, about 3.9 tonnes of NOx is emitted per day (1,180 tonnes per year), thus 0.6 kg NOx per tonne of clinker.

Assuming an initial NOx level of 1,100 mg/m^3, about 12.9 tonnes of NOx is reduced per day (3.856 tonnes per year), thus 2,07 kg NOx per tonne of clinker.

NOx is destroyed in an oxidizing atmosphere be a two step process that can be summarized as: $4\ NH_3 + 4\ NO + O_2 \rightarrow 4\ N_2 + 6\ H_2O$ (molar NH_3/NO ratio is 17/30 = 0.56). 2.07 kg specific NOx reduction expressed as NO_2 is equivalent to 1.35 kg NO reduction per tonne of clinker (molar ratio of NO/NO_2 is 30/46 = 0.65).

For the reduction of 1.35 kg NO per tonne of clinker, in a stoichiometric reaction 0.75 kg ammonia per tonne of clinker is needed. Due to kinetics, in Slite a stoichiometric factor of 1.5 was needed to achieve the NOx reduction mentioned above. Based on this, for 1.35 kg NO reduction per tonne of clinker an injection of 1.1 kg ammonia per tonne of clinker is needed.

Ammonia is used as 25% dilution, thus 4.4 kg ammonia water per tonne of clinker was injected, summing up to 27,280 kg of ammonia water per day (8,184 tonnes per year). Due to transport to the island of Gotland, the ammonia water price is higher than usual. In the example the price was about 130 Euros per ton, resulting in ammonia water costs of 3,546 Euros per day and 1,063,920 Euros per year (0.47 Euro per tonne of clinker).

Electricity and maintenance costs for the SNCR system is estimated with 130 Euros per day, resulting in annual costs of 39,000 Euros (0.02 Euro per tonne of clinker).

Investment costs for the SNCR system are 1,100,000 Euros. Assuming a depreciation of 20 years and capital costs of 10%, annual investment costs result in 110,000 Euros.

Annual investment and operational costs sum up with 1,212,920 Euros. This is equivalent to 0.53 Euro per tonne of clinker and 257 Euros per tonne of NOx reduction.

No information about cost savings resulting from replacing primary energy carrier by co-incineration of waste is noted.

Based on RiskPoll calculation, environmental and health benefits of 3.856 tonnes of NOx emission reduction sum up with 1.8 m Euros.

3.11. Electric arc furnace Luxembourg

3.11.1. Description of the plants

The Electric Arc Furnace (EAF) of ARCELOR/MITTAL in Esch-Belval (Luxembourg) has a capacity of 155 t per charge. The tap to tap time[96] was in the year 2004 around 70 minutes. The off gas volume is ~820 000 m^3/h. The off gas cleaning system consists of a post combustion, wet quench, activated carbon and a fabric filter. Fugitive emissions are minimised by housing of the furnace and high volume air suction system

The tyre waste is introduced into the process via the scrap basket.

Since March 2006 tyre waste has been co-incinerated in the electric arc furnace. The co-incineration was initially permitted for a trial with an amount of maximal 5 000 t of tyre waste. In fact 1342 t have been used in two trial phases of six months each (between 3.5 and 4 kg of tyres per tonne of liquid steel) (all information according to [ARCELOR pers.com. July and August 2007]).

The permitting authority set the following emission limit values for these trials:

[96] In the batch process of an electric arc furnace this describes the time from charging to charging of the oven.

Table 61: Emission limit values for the EAF Belval for the co-incineration of tyres [Ministère de l'environnement Luxembourg, Administration de l' environnement, Luxemboug, 01 Mars 2006]

	Permitted ELV (periodic measurement)	WID Annex II.3 and II.V
	mg/Nm³ (unless otherwise stated)	mg/Nm³ (unless otherwise stated)
Dust	5	10
Hg	0.05	0.05
Cd + Tl	-	0.05
Cd	0.05	(see Cd + Tl)
As	0.25	(see Sum HM)
Co	0.25	(see Sum HM)
Ni	0.25	(see Sum HM)
Cr	1.25	(see Sum HM)
Cu	1.25	(see Sum HM)
Mn	1.25	(see Sum HM)
Pb	1.25	(see Sum HM)
V	1.25	(see Sum HM)
Zn	2.5	(see Sum HM)
Sum HM	3.5	0.5
HF	5	1
HCl	30	10
SO_2	-	50
NOx	-	200/400
TOC	-	-
Dioxin + Furan	0.1 ng/Nm³	0.1 ng/Nm³
PAH	0.05	-
PCB	1µg/Nm³	-
CO	-	50

According to ARCELOR/MITTAL the trials have been successful and the company has applied for a regular permit.

3.11.2. Costs and benefits

According to ARCELOR/MITTAL no change of the emission situation has been observed during the trials and no changes are expected for the permanent use of tires as planned by the company. It has been observed that the TOC value has been higher in the raw gas in the first 10 minutes of a charge. This has been solved by an adaptation of the post combustion [ARCELOR/MITTAL pers.com. August 2007].

No additional off gas abatement measures have been taken to meet the ELV and no investments have been necessary for charging the tyres.

Information about the economic situation with the substitution of the use of tyres in the electric arc furnace has not been made available by the company.

In order to appraise economic benefits from the co-incineration of tyres under a WID permit a theoretical model based approach has been applied. Cost savings result from extra payment the steel plant gets for the waste tyres and from reduced the costs for buying hard coal by half of the weight of the tyres. No investment costs are necessary for the use of tyres. In this model approach it is assumed that operating costs do not differ significantly from a situation where anthracite is used instead of waste tyres. In reality increased costs can be expected from the fact that one additional input must be handled (tyres in addition to the remaining amount of anthracite) and that twice the amount of waste tyres compared to anthracite is necessary (substitution rate waste tyres : anthracite = 2:1 meaning that 2 t of waste tyres replace 1 t of anthracite). It is assumed that extra payments for tyres are between 30 €/t and 60 €/t. The used amount of tyres is 550 kg/charge, resulting in extra payment between 16.5€/charge up to 33 €/charge. The costs for anthracite are between 40 €/t and 70 €/t. The saved amount of anthracite is 275 kg/charge, resulting in cost saving between 11 €/charge and 19.25 €/charge. The resulting cost savings are in the range of ~28 € to 53 € per charge[97].This results in specific cost savings between 18 cent and 34 cent per tonne of liquid steel.

Assuming a price range for hot rolled products from the electric arc furnace between 120 €/t and 180 €/t (including a scrap surcharge of 100 €/t) cost savings per tonne of hot rolled product can be roughly estimated between 0.1% and 0.3%.

Concluding it can be stated that in this case the WID does not lead to additional costs but at the same time no environmental benefits from the application of the WID can be shown.

[97] Extra payments for tyres: min. 30 EUR/t, max 60 EUR/t, used amount of tyres: 550 kg/charge, resulting in extra payment between 16.5 EUR/charge up to 33 EUR/charge; costs for hard coal min. 40 EUR/t, max. 70 EUR/t, saved amount of hard coal: 275 kg/charge, resulting in cost saving between 11 EUR/charge and 19.25 EUR/charge.

3.12. Waste co-incineration in a lime kiln

3.12.1. Description of the plant

The plant is owned by the company Lhoist[98] and is operating with 9 kilns. It is equipped with a bag-house filter since 1999 (before using waste) and was upgraded in 2003 with the emission control techniques for the co-incineration of waste. No additional waste gas treatment techniques were installed.

The production capacity of the plant is 1950 tonnes of lime per day, 712 000 t/year. For the production of 1 tonne of lime the plant uses the following inputs: 1.78 t of primary raw material, 12 804 t of fossil fuel equivalent to 2 854 768 GJ, 3 284 t of waste fuel equivalent to 136 864 GJ.

The fossil fuel consists of natural gas, light oil and heavy fuel oil, the waste fuel consists mainly of solvents (3284 t/y in 2006).

The permit for waste co-incineration was granted in 2003 for 40% of the total energy input.

3.12.1.1. Costs

For waste co-incineration the following investment related to the emission control done:

- Additional measurement equipment:
    - Multi-gas infrared analyser (161 000 € in 2002 and 100 000 € in 2005)
- Additional equipment:
    - Storage tank for waste fuels (925 000 € in 2007)
    - Retention tank (275 000 € in 2003)

The total investment cost for the Multi-gas infrared analyser was 261 000 €.

The investment per year for a 10 years depreciation period is about 32 400 Euro, including an assumptive interest rate of 10%. The costs for the additional equipment are not taken into account as those are not directly related to emission reduction measures induced by the co-incineration of waste and the requirements of the WID.

The yearly costs of operating the Multi-gas analyser have been indicated with 3 400 € per year.

98 All information provided in this chapter is provided by Lhoist [pers. com. September 2007].

The costs related to the measurements equipments consists of yearly investment costs of about 32 400 Euros and additional operational costs of about 3 400 Euros, adding up to 35 800 Euros.

No information is available about the level of profits resulting from the substitution of fossil fuels by waste.

3.12.1.2. Emission limit values and performance

The following table shows the emission limit values before and after permitting according to the requirements of the WID for co-incineration

Table 62: Comparison of emission limits and emissions of the lime plant with with/without co-incineration?

	Limit value [mg/m³]		Average emission value [mg/m³]					
	until 2003	from 2003	2001	2002	2003	2004	2005	2006
Dust [mg/m³]	30	24	18.4	3.0	4.7	18.9	3.5	17.0
SO_2 [mg/m³]	-	67	3.5	1.9	1.2	4.4	5.4	2.7
NOx (as NO_2) [mg/m³]	-	1200	153	146	146	180	161	145
CO [mg/m³]	-	900	-	704	445	240	55	1263[99]
TOC [mg/m³]	-	19	18.0	6.0	5.9	6.6	7.0	2.4
HCl [mg/m³]	-	10	-	3.3	1.7	1.5	3.7	1.7
HF [mg/m³]	-	1	-	0.20	0.38	0.23	0.20	0.05
Hg [mg/m³]	-	0.05	-	0.0031	0.0032	-	0.002	0.043
Cd + Tl [mg/m³]	-	0.05	-	-	0.0043	-	0.0001	0.0014
Sum of As, Ni, Cr, Co [mg/m³]	-	-	-	-	-	-	-	-
PCDD/F [ng/m³]	-	0.1	-	0.011	0.0005	0.0001	0.0011	0.014
Grey: base value/year, red: higher values compared to base year, green: lower values compared to base year. "-" = no information submitted by plant operator								

The emission values do not show relevant difference if compared to 2002. Since no specific abatement technique has been installed for the co-incineration of waste no reduction of emissions can be observed. However, an improvement of the measurement system has been realised and thus a reduction of the risk to exceed the emission limit values can be expected.

[99] In 2006 one kiln experienced upsets during the second stack measurement which exceeded the ELV for CO. According to Lhoist the CO went back to order after the measurement but the measurement itself was not redone. Therefore the annual average CO value from 2006 is not representative for normal operations.

3.13. Waste co-incineration in the coal power station Fusina of ENEL nearby Venice (Italy)

3.13.1. Description of the plant

The coal power station is situated in Fusina near Venice in Italy, operated by ENEL. Actually in Fusina power plant about 35,000 tonnes of waste fuels are used. For waste co-incineration no additional waste gas treatment and monitoring systems have been implemented.

3.13.2. Costs and benefits

The following table compares emissions of coal combustion and emissions of coal combustion with waste co-incineration.

Table63: Comparison of emissions for coal combustion and co-incineration with waste fuels at Fusina power station

		Coal (Blank) - Experimental phases			Coal-RDF co-combustion (9 tons/h)		
Parameters	MU (6%O2)	1	2	Average	experimental phase 2	industrial phase	Average
Total Dusts	mg/m³	9.1	1.1	5.1	2.83	0.63	1.73
Hydrochloric acid	mg/m³	1.3	0.63	0.965	5.89	2.8	4.345
Hydrofluoric acid	mg/m³	4.3	1.91	3.105	1.585	2.24	1.9125
Antimony (Sb)*	mg/m³	0.002	<0.002	0.002	<0.002		
Arsenic (As)*	mg/m³	0.002	<0.002	0.002	<0.002		
Chromium (Cr)*	mg/m³	0.005	0.004	0.0045	0.006		
Cobalt (Co)*	mg/m³	0.002	<0.001	0.002	<0.001		
Cupper (Cu)*	mg/m³	0.005	0.004	0.0045	0.005		
Manganese (Mn)*	mg/m³	0.027	0.018	0.0225	0.083		
Nickel (Ni)*	mg/m³	0.008	0.025	0.0165	0.004		
Lead (Pb)*	mg/m³	0.004	0.003	0.0035	0.004		
Vanadium (V)*	mg/m³	0.006	<0.001	0.003	0.001		
*sum	mg/m³			0.0605	0.108	0.0993	0.1
Mercury (Hg)^	mg/m³	0.0006	0.0024	0.0015	0.0015	0.00088	0.00119
Cadmium(Cd)°	mg/m³	<0.001	<0.001	<0.001	<0.001		
Thallium (Tl)°	mg/m³	<0.002	<0.002	<0.002	<0.002	0.00133	<0.003
°sum	mg/m³	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
PCDD+PCDF	pgI-TEQ/m³	0.179	0.013	0.096	0.778	1.6	1.189
PAHs	ng/m³	216.7	560.1	388.4	510	60	285
PCB	ng/m³	0.348	0.0625	0.20525	0.177	0.12	0.1485
NOx	mg/m³			170		146	146

[ENEL 2007]

Related with waste co-incineration, the construction of a new building and civil works amounted to investment costs of about 0.8 to 1.0 m Euro (1999 - 2002) equivalent to 23 to 29 Euro per tonne of co-incinerated waste.

Investment costs directly related with waste co-incineration were about 4.5 m Euro for receiving, milling and feeding as well as for the installation of a new waste gas monitoring system. More differentiated data are not made available.

Operational costs consist of (not individually specified):

- handling of fuel,
- control of waste characteristics,
- other environmental controls (no continues measures),
- controls on corrosion of the boiler,
- additional costs of DeSOx operating,
- other general costs.

The co-incineration implies about 1.58 m Euro of operational costs per year resulting in specific operational costs of 40 - 50 Euros per tonne of waste. [ENEL 2007]

Assuming a depreciation of 10 years and capital costs of 10 %/y for the investment directly related with waste co-incineration (4.5 m Euro), the total costs for investments are 675,000 Euro/y equivalent to 19.30 Euro per tonne of waste.

Capital costs directly related with the waste co-incineration (monitoring but also costs for receiving, milling and feeding) and operational costs as listed above end up with about 2.3 m Euro per year, equivalent to ~64 Euro per tonne of waste.

At the moment it is planned to increase the capacity for waste co-incineration from 40,000 tonnes per year to 80,000 tonnes per year. This will imply investment costs of about 5 m Euro. [ENEL 2007]

The additional costs related to waste co-incineration are reduced by cost savings from the substitution of primary fuels by 35,000 tonnes of waste, which can be estimated with about 40 Euro per ton, equivalent to 1.4 m Euro.

The environmental benefit can not be monetized. No improvement of the waste gas abatement system was installed but an improvement of the monitoring system by the continuous mercury monitoring. Since before waste co-incineration mercury emissions from the coal firing have not been a critical parameter, the environmental benefit of the continuous mercury monitoring represents only a measure to monitor waste co-incineration and can not be considered as an improvement in comparison with the situation before waste co-incineration.

3.14. Waste co-incineration in a coal power station (Germany)

3.14.1. Description of the plant

The lignite coal power station is situated in Germany, operated by a multinational company. The capacity is 3,000 MW, produced by 6 boilers of 500 MW.

Since 2004, waste co-incineration is permitted in two boilers of 500 MW each for a maximum of 400,000 tonnes of waste (max. 65 tonnes per hour in each boiler and max. 3.6 weight-% of coal supply).

The plant is equipped with an electrostatic dust filter and a flue gas desulphurisation scrubber. After a test and monitoring period of waste co-incineration, no need for additional waste gas treatment was concluded.

Additional monitoring had to be installed for continuous mercury measurement. Additional periodic monitoring is necessary for HF, HCl, Benzo(a)pyrene and the heavy metals.[100]

The following waste fractions may be used:

- 19 12 01 (paper and card-board)
- 19 12 07 (non-contaminated wood)
- 19 12 08 (textiles)
- 19 12 10 (waste derived fuel)
- 19 12 12 (other waste (including mixed material) from mechanical treatment of waste)

[100] Continuous measurement of TOC and CO is required also without waste co-incineration by German implementation of the Large Combustion Plant Directive (13.BImSchV)

Table 64: Waste input parameters for co-incineration in a German coal power station

Emissions	Limit value	
Continuous measurement	(for 350 days/year of operation with 320,000 Nm^3/h)	
Net calorific value	min. 9 – max. 25	MJ/kg (as received)
Ash content (as received)	< 35	weight-% (as received)
PCB	< 50	mg/kg (dry matter)
PCP	< 5	mg/kg (dry matter)
Chlorine	< 2	weight-% (dry matter)
Fluoride	< 0.5	weight-% (dry matter)
Sulphur	< 5	weight-% (dry matter)
Cadmium	max. 9	mg/kg (dry matter)
Thallium	max. 2	mg/kg (dry matter)
Mercury	max. 2	mg/kg (dry matter)
Arsenic	max. 8	mg/kg (dry matter)
Cobalt	max. 30	mg/kg (dry matter)
Chromium	max. 450	mg/kg (dry matter)
Copper	max. 8,000	mg/kg (dry matter)
Manganese	max. 700	mg/kg (dry matter)
Nickel	max. 160	mg/kg (dry matter)
Lead	max. 2,000	mg/kg (dry matter)
Antimony	max. 100	mg/kg (dry matter)
Vanadium	max. 40	mg/kg (dry matter)
Tin	max. 120	mg/kg (dry matter)

[Permit 2004]

3.14.2. Costs and benefits

The following table shows emission limit values for co-incineration of the plant as well as limit values of national legislation for coal power stations (“13. BImSchV”).

Partly stricter limit values have been applied for instead of lower limits of relevant national legislation for waste incineration and co-incineration (“17. BImSchV”).

Table 65: Emission limit values for co-incineration in a German coal power station

Emission limit values				
Regulation	17.BImSchV (with co-incineration)			13.BImSchV (no co-incineration)
Measurement	continuous		periodic	continuous (c) or periodic (p)
Parameter	daily average limit value	half-hour limit value	limit value	limit value [5]
	all in [mg/m³] but PCDD [ng/m³], for 273 K, 101,3 kPa, 6% O2			
Total dust	10	30		20 (c)
SO_2	369 [1]	738		200 or 300 [6] (p) or 400 [7] (p)
	min. 95% reduction			min. 95% reduction
NOx	200 [2]	400		200 (c)
CO	233	466		200 or 250 [8] (p)
TOC	10	20		-
Hg	0.03	0.05		0.03 (c)
HCl			20	-
HF			1	-
Cd+Tl			0.03 [3]	0.05 (p)
Sum of As, Cd, Co, Cr, Benzo(a)pyren			0.05	0.05 (p)
Sum of heavy metals			0.5	0.5 (p)
PCDD/F			0.05 [4]	0.1 (p)

1) According to national regulation on fuel with elevated sulphur content
2) Voluntary application of stricter national limit value for large combustion plants instead of application of the mixing rule
3) Voluntary application instead of national limit value of 0.05 ng/m³
4) Voluntary application instead of national limit value of 0.1 ng/m³
5) Continuous monitoring: daily average limit values; half-hour limit values are twice the value.
6) 300 mg/m³ for existing plants (permitted until 2002) with a capacity of more than 300 MW
7) 400 mg/m³ if emission limit value due to elevated sulphur content of the fuel can not be achieved with proportional effort
8) 250 mg/m³ for existing plants (permitted until 2002) with a capacity of more than 100 MW

[Permit 2004]

Periodic measurements have to be done each year on three days. Continuous measurement of TOC may be renounced if it can be proved that TOC values are always complied with if CO values are not exceeded.[101]

Related with waste co-incineration, the investment into two measurement instruments for continuous mercury monitoring was reported with 120,000 Euros. Assuming an interest rate of 10% and a depreciation of 10 years, annual additional costs for mercury measurement are about 18,000 Euros. Additional costs per year for periodic measurements at three days (HF, HCl, heavy metals and PCDD/F) are estimated with 7,500 Euros, resulting in additional measurement costs of about 25,500 Euros.

[101] Waste Incineration Directive requires continuous monitoring of TOC in Article 11, 2 a. No further assessment of this information was possible in the project runtime.

Additional costs of waste co-incineration are reduced by profits from substitution of lignite by waste. Assuming revenue of 60 Euro per tonne of waste the reception of 400,000 tonnes results in an annual profit of 24 million Euros. Assuming 5 million tonnes of lignite consumption for two 500 MW boilers and costs of 28 Euro per tonne of lignite, the annual profit of 3% lignite substitution is 4.2 million Euros. This results in total yearly profits of about 28.2 million Euros.

An environmental benefit cannot be monetised because no information on emissions before and after start of co-incineration was available. No improvement of the waste gas abatement system was installed but an improvement of the monitoring system by the continuous mercury monitoring. Since before waste co-incineration mercury emissions from the lignite firing have not been a critical parameter, the environmental benefit of the continuous mercury monitoring represents only a measure to monitor waste co-incineration and can not be considered as an improvement in comparison with the situation before waste co-incineration.

3.15. Waste co-incineration in the waste wood combined heat and power plant of ELAN in Begunje (Slovenia)

3.15.1. Description of the plant

The combined heat and power (CHP) waste wood co-incineration plant of ELAN is situated in Begunje in Slovenia. ELAN produces sports equipment comprising boots, skis and snow boards among others.

The incineration plant is operating since 2002, replacing a 30 year old CHP plant for waste wood, which had been operated without any waste gas cleaning.

The new CHP plant consists of a grate heating and a pyrolysis chamber, operated with additional injection of natural gas achieving 850°C. Waste gases are cleaned via a multi-cyclone stage and by a bag house filter. The main fuel consists of about 920 tonnes of waste wood per year, co-incinerated with about 9 tonnes of plastic waste per year. [ELAN 2007]

3.15.2. Costs and benefits

The following table compares emissions of the former plant (operated only with waste wood) and the new plant (operated with waste wood and plastic waste).

Table 66: Comparison of emissions of old CHP plant and co-incineration CHP plant of ELAN in Slovenia

Parameter	unit	2001 (old installation: only waste wood input)	2006 (new installation: waste wood and plastic waste input, same capacity)	Difference 2001 - 2006
Total dust	kg/year		64	--
NO_x, as NO_2	kg/year	4 960	5 100	+ 140
SO_x, as SO_2	kg/year	475	290	- 185
CO	kg/year	15 656	120	- 15 536
TOC	kg/year		22	--
HCl	kg/year		310	--
HF	kg/year		9,1	--
Hg	kg/year		<0,016	--
Cd, Tl	kg/year		< 0,098	--
Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn	kg/year		1,41	--
PCDD/F (TEQ)	mg/year		1,0	--

[ELAN 2007]

The total investment of the plant was 690,000 Euro. The investment related with the waste gas control was 120,000 Euros. Assuming a depreciation of 10 years and capital costs of 10 %/y, the investment costs results in 18,000 Euro. The additional operating costs are estimated with about 47,000 Euros per year. [ELAN 2007]

These figures amount in total annual costs of waste gas control of 65,000 Euros. The health and environmental benefits can only be calculated for SO_2 and NOx and since the NOx value increased between 2001 and 2006 the monetized annual benefit amounts only to ~ 315 Euro stemming from the reduction of SO_2 emissions based on RiskPoll.

3.16. Waste Co-incineration in FiboExclay expanded clay production of Maxit Group in Ølst (Denmark)

3.16.1. Description of the plant

The following example presents data of the FiboExclay plant of Maxit Group, situated in Ølst/Denmark. The plant is operating since 1962 with 2 kilns, both operating with the same waste gas treatment:

- Electrostatic precipitator (since 1980) and
- $Ca(OH)_2$ bag house filter (since 2005).

The production capacity of the plant is 720 tonnes of expanded clay per day or 238,000 t/year. The turn over of the plant is 11.4 m Euro (85 m DKR) per year.

For the production of 1 m^3 of expanded clay the plant uses the following inputs: 660 t of clay, 0.005 t of additives, and 0.04 t of fuel (equivalent to 1000 MJ).

The clay originates from own local clay pit. The additives consist of heavy oil, iron mud and alumina products. The fuel consists of 60 % primary fuel as coal and gas, and 40% waste fuels. The waste fuels consist of meat and bone meal and solvents. Hazardous waste will always represent less than 40% of the heat release.

The permit for waste co-incineration was granted in 2005 for 100 % of the total energy input. The permit was finally approved in 2007 (due to minor issues relating noise and vibrations).

3.16.2. Costs and benefits

The following table shows the emission limit values and the measurement results before and after waste co-incineration.

For setting the emission limit values the mixing rule was applied as following: The C_{proc} values were determined from the national legislation as following: Total dust: 50 mg/Nm^3, SO_2: 400 mg/Nm^3, NOx: 1200 mg/Nm^3, CO: 400 mg/Nm^3, TOC: 300 mg/Nm^3, HCl: 100 mg/Nm^3. [EXCA 2007]

Table 67: Comparison of emission limits and emissions of Ølst expanded clay production without/with co-incineration

	Emission limit value [mg/m³] PCDD/F [ng/m³]		Average emission value [mg/m³]		Comparison 2005 – 2006 (for 350 d/y, 24h/d)	
	until 2005	from 2006	2005	2006		
Total dust	50	34	20	3	-12.8 t	-85%
SO_2	400	261	*	332	-	-
NOx	1200	1200	653	877	+168.4 t	+34%
CO	400	400	259	250	-6.8 t	-3%
TOC	300	185	47	30	-12.8 t	-36%
HCl	100	64	89	43	-34.6 t	-52%
Hg	0.1	0.08	*	*		
Cd+Tl	0.05	0.05	*	*		
other metals	0.5	0.5	*	*		
PCDD/F	0.1	0.1	*	*		
Average volume stream Nm³/h, normal conditions (101,3 kPa, 0°C), 11% O_2			89 500			
* Measurement values have not been provided						

[EXCA 2007], [MAXIT 2007]

Emission limits are calculated and adjusted continuously based on the fuel mix or rather the energy substitution by waste in the process. A post calculation is made to document the exact emissions limits based on the delivered amounts of fuel and waste. [EXCA 2007]

Data on SO_2 average emissions of 2005 was not available; data on heavy metal emissions and emissions of PCDD/F have not been provided.

For waste co-incineration, about 1.1 m Euro was invested for storage and pre-treatment of meat and bone meal, 1.1 m Euro for storage and handling of solvents (8 m DKR in total). [EXCA 2007]

For waste gas control, the following investment related to co-incineration was done:

- new waste gas abatement stage ($Ca(OH)_2$ injection and bag house filter): 1.34 m Euro (10 m DKR);
- continuous waste gas measurement for dust, SO_2, HCl, TOC, CO, NO_x: 0.134 m Euro (1 m DKR).

The total investment costs result in about 1.5 m Euro. Assuming a depreciation of 10 years and capital costs of 10%/y, the resulting investment costs are 225,000 Euros. [EXCA 2007]

The yearly operational costs related with waste co-incineration are:

- Purchase/disposal of $Ca(OH)_2$: 268 T€ (2 m DKR),
- Electrical power for new gas cleaning system 160 T€ (1.2 m DKR),
- Maintenance incl. new bags: relevant data are not available yet,
- Additional measurements: 6,720 Euro (50,000 DKR).

The yearly operational costs add up with 435,000 Euro.

The total annual costs (capital and operational costs) are about 660,000 Euro (reduced by: economic benefit from waste reception). [EXCA 2007]

No information is available about the level of economic benefits from the substitution of fossil fuels by waste.

For dust and TOC significant emission reductions can be observed. Based on RiskPoll calculations, the health and environmental benefits add up to about 135,000 € per year.

No information is available whether increased NOx emissions result from waste co-incineration. Additional health and environmental damages of increased NOx emissions, calculated with RiskPoll, result in 358,000 € based on RiskPoll.

The total effect on health and environment resulting from differences between dust, TOC and NOx emission levels of 2005 and 2006 is an additional damage cost of 223,000 €.

3.17. Summary

Following table shows the costs of implementing the WID and the environmental benefits/damages per plant.

Table 68: Overview of the costs of implementing the WID and the environmental benefits/damages (negative figures regarding total annual costs = cost savings)

	Dust	SO_2	NOx	Cd	Hg	PCDD/F	NMVOC	**Monetised health & env. benefits (€2000/y)**	Investment costs (€/y)	Additional opera-tional costs (€/y)	**Total annual costs for WID compliance (€/y)**	**Economic benefit from fuel switch (€/y)**
EAF (Luxembourg)	no environmental benefit identifiable										0	260 000
DWI Hungary	3 647 511	1 262 447	1 505 907	2 262	502 600	600 000	4 496	7 525 224	4 000 000	3 400.000	7 400.000	n.a.
MWI (France)			254 480			11 250		265 730	3 000 000	no data	-	n.a.
HWI Zentiva (Czech Republic)						60 000		60 000	63 675	17 700	81 375	n.a.
HWI TOP EKO (Czech Rep.)						7 250		7 250	33 600	no data	-	n.a.
DWI Indaver (Belgium)			2 492 997					2 492 997			598 000	n.a.
medium NOx, medium cement plant (central Germany)			2 266 009					2 266 009			199 248	2,9 million
high NOx medium cement plant (south Germany)			4 971 354					4 971 354			365 280	2.9 million
medium NOx, large cement plant (Germany)			5 588 587					5 588 587			470 600	5.8 million
Cement plant, (Sweden)			1 828 990					1.828.990	110 000	1 212 920	1 322 920	No data
Lime plant	no environmental benefit identifiable								32 400	3 400		No data
Power station (Italy)	no environmental benefit identifiable								675 000	2 300 000	2 975 000	1.4 million
Power station (Germany)	no environmental benefit identifiable										25 500	28 million
Power plant ELAN, (Slovenia)		934	-619					315	18 000	47 000	65 000	No data
ExClay Maxit (Denmark)	120 785		-358 276*				14 387	-223 104** (135 172***)	225 000	435 000	660 000	No data

* no information about whether increased NOx emissions result from waste co-incineration ** provided that increase of NOx emission results from waste co-incineration *** without additional NOx damage costs

4. Future development

Information about problems related to the implementation of the WID has been gathered by questionnaires sent out to stakeholders, expert interviews, workshops and literature research (see chapter 2).

Identified issues have been discussed with stakeholders inter alia in a number of workshops and direct meetings and personal interviews with experts and European and national stakeholders and associations as well as via exchange of written information.

This chapter summarises in a first step issues raised by the stakeholders regarding the implementation of the WID and the experience from day to day practice.

In a second step selected issues are analysed in detail and the results of the analysis of impacts of policy options related to those issues are presented.

4.1. Issues with the implementation of the WID

4.1.1. General perspective

A basic issue raised by stakeholders was the uncertainty regarding the application of the WID on specific types of installations and certain types of waste as well as regarding the decision on whether a waste shall be considered as (co-)incinerated or not[102]. Exemplary cases were

- the use of high calorific wastes as expansion agent in the ceramic industry,
- the cleaning of equipment or the cleaning of soil from organic contaminants,
- the use of waste that has a certain percentage of organic substance and a share of mineral components being used or as fuel or as raw material in cement kilns.

In the view of the stakeholders the application of the WID is, inter alia, affected by the uncertainty about the status of a material as waste or as a non-waste. A tendency was feared by some stakeholders that some waste types will become non-wastes in the future and “escape” the requirements of the WID.

102 Comment: the definition of 'co-incineration plant' in the WID only covers plants which use waste as a regular or additional fuel or in which waste is thermally treated for the purpose of disposal other possible recovery operations are thus not covered.

Two different possibilities for amendment of the scope of the WID have been highlighted by stakeholders:

In a medium term perspective it was suggested to change the scope of the WID in a way that it would apply to all thermal processes where organic substance in wastes are oxidised in an exothermal process. Subjective elements like considerations about the purpose of the use of waste (like for example the distinction whether a waste is used as fuel or whether a recovery as material happens in the process) would be minimised as far as possible. Reference was made to an approach of one Member State which defined the scope of the national implementation of the WID in a way that besides wastes also similar high calorific solid and gaseous substances are covered. This provision is accompanied by a list of materials which are excluded from the scope (negative list). The text box at the right shows such a list.

Primary energy carrier not covered by the national regulation

- coal
- coke including petroleum coke
- coal briquettes
- peat briquettes
- peat
- untreated wood
- emulsified natural bitumen
- fuel oil except fuel oil EL
- methanol
- ethanol
- untreated vegetable oil
- gaseous fuels (especially coke oven gas
- pit gas
- steel gas
- synthesis gas
- refinery gas
- gas from oil production
- sewage plants and biogas) untreated natural gas
- liquid gas
- gas from public gas nets or hydrogen

[Annex 1.2 of German 4.BImSchV]

In a long term perspective some stakeholders mentioned as an option to apply the requirements of the WID to all thermal processes treating waste regardless whether a material is used as a raw material or whether it is incinerated. Exemptions from this broad definition shall then be defined for specific processes like for example for the wet oxidisation process in the precious metal industry.

As an interim solution some stakeholders proposed to develop threshold values (e.g. of minimum organic content, minimum calorific value) for the differentiation between the two categories of materials.

Comment

The definition of waste as well as the “end of waste” criteria for waste treatment processes are discussed in the context of the Waste Framework Directive which is currently under review. This issue is not further discussed in the scope of this study.

4.1.2. Need for specific provisions for activities co-incinerating waste not covered by Annex II.1 or II.2 regarding value C, C_{proc} and/or C_{waste}

4.1.2.1. Lime industry

Issue

It was stated by EULA that the missing of specific provisions in the WID for lime kilns results in inappropriate ELV because certain substances in the off gas mainly stem from raw materials and are process specific (e.g. some heavy metals). Requiring the ELV of Annex II.3 (no application of the mixing rule) and Annex V (with application of the mixing rule) of the WID to be met for those parameters is said to restrict the co-incineration of waste in this industry sector more than for other sectors (e.g. cement industry)[103].

It was also stated that special provisions for ELVs for this sector are not included in the WID because no sufficient data about the sector were available at the time when the WID was developed.

Short analysis

About 18 plants of the lime industry in Europe have WID permits[104] and ~ 50 kilns co-incinerate wastes. The amount of waste co-incinerated was estimated to be 262,000 t in 2005 [EULA 2007]. The contribution of EULA to the BREF review states that “4 % of the whole energy consumed by the European lime industry” and that the thermal substitution rate varies between 10% and 100% in those kilns where waste is co-incinerated [EULA 2006-1].

Depending on the countries, permits for lime kilns were granted sometimes according to the special provisions for cement kilns (annex II.1 of the WID) or for combustion plants (annex II.2 of the WID) or for industrial sectors not covered under II.1 and II.2.

[103] Comment: Additional problems regarding a missing level playing field might result if Member States are setting very different C_{proc} values (which lead to differences in the C values). However, the focus of the stakeholder was more on the application of the values C and C_{waste}.

[104] WID permits means that the permits include specific requirements based on the national transposition of the WID.

4.1.2.2. Primary copper plants

Issue

The emission situation of primary copper smelters is largely influenced by raw materials that contain substances which are regulated by the ELV of the WID (e.g. heavy metals). It was stated by a plant operator that the WID requirements prohibit the use of waste in primary copper smelters, because the WID ELV can only be achieved with high investments in off gas abatement techniques. High calorific wastes that are used in this sector are for example waste oil and plastic wastes.

Short analysis

The treatment of sulphuric copper ore in primary copper smelters results in very high concentration of sulphur oxide in the off gas.

The oxidisation of the sulphuric components of the copper ore is an exothermal process.

In European copper plants the off gas is treated in a sulphuric acid plant where sulphur oxide is removed from the off gas. Usually the raw off gases from different parts of the plant are merged and treated together in a common off gas abatement system.

The thermal treatment of the copper ore also results in relatively high concentrations of heavy metals which are reduced in the off gas abatement system.

When the WID is applied the emission limit values C of Annex II.3 of 0.05 mg/m^3 for Cd+Tl and Hg and of 0.1 ng/m^3 for PCDD/F are valid. The ELVs for the other pollutants are applied via the mixing rule.

In one European copper smelter the company decided not to co-incinerate waste in order not to be forced to fulfil the ELV of Annex II.3. In another copper smelter co-incineration of waste is permitted based on the national implementation of the WID. In the latter example the portion of V_{waste} is very low compared to V_{proc} (probably far below 5%). Thus the application of the mixing rule does not result in a significant decrease of the value C compared to C_{proc}. For the ELV of Annex II.3 exemptions might have been permitted but no information is available. It might be the case that no additional monitoring requirements compared to the former permit are imposed.

However, no sufficient information is available to further clarify the issue and possible ways forward.

4.1.2.3. Ceramic industry

Issue

It was stated by EXCA that difficulties exist to meet the requirements of the WID especially for the parameters CO, TOC and SO_2 when waste is co-incinerated in expanded clay kilns and the WID is applied. It was stressed that even though these substances do not stem from co-incinerated waste efforts must be taken to reduce their concentration in the off gas. In addition the point was raised that different national approaches are taken for permitting co-incineration of waste in expanded clay kilns (like e.g. applying the provisions for cement kilns or applying exclusively Annex V or the approaches taken to set C_{proc}). This would result in differences in the requirements. Therefore no level playing field would exist.

Short analysis

Emissions of the three substances under discussion result to a large extent from the raw materials used in the process. Additives used in the process for the expansion of the clay play a relevant role regarding the parameters TOC and CO[105]. SO_2 results mainly from sulphuric components of the raw materials.

The number of plants is relatively low and the amount of waste co-incinerated relatively small. Around 30 expanded clay rotary kilns in around 20 plants are co-incinerating about 225 000 tonnes of waste.

The relevance of co-incineration of waste for the individual plant is high because energy costs make up a high portion of the overall production costs (~1/3 according to EXCA) that can be reduced when waste is used.

4.1.2.4. Primary steel industry

Issue

The gaseous output from the thermal treatment of waste in a blast furnace is the blast furnace top gas. The ELV of the WID can not be applied directly to the blast furnace top gas as this is not an incineration process. However, the whole process can be considered as co-incineration if the product of the thermal treatment of waste is subsequently incinerated (cf. definition of co-incineration plant).

[105] The use of waste for expansion purposes is not permitted as co-incineration of waste but as a material recovery.

Short analysis

The blast furnace top gas is incinerated in a variety of subsequent processes (e.g. cowpers, power plants, coke ovens)[106]. In several cases installations where the blast furnace top gas (BTG) is incinerated are not on the same site, not run by the same operator or not under the same environmental permit. Under the WID, for blast furnaces using high calorific waste, the mixing rule of Annex II must be applied for calculating the ELVs for the installations where the gas from the blast furnace is incinerated. This means that the ELVs may apply at different stacks, depending on where the BTG is incinerated.

Effects in the off gas of e.g. power plants resulting from the use of waste in blast furnaces are often not measurable because of the relatively small mass flows resulting from the waste[107].

While the number of blasts furnaces in Europe is small the potential for using waste is probably high (500 000 to 800 000 tonnes per year in a mid term perspective).

The process of blast furnaces and especially the emission situation differs in terms of complexity from most of the other processes covered by the WID. Similarities can be found with waste gasification and pyrolysis plants.

4.1.2.5. Concluding remark

For most of the specific issues referred to in this section either low mass relevance has been asserted and/or the issue and/or the extent of the issue could not be clarified sufficiently.

Thus elevated priority was only given to the blast furnace process and the ceramic process regarding the further analysis in the course of an impact analysis.

[107] Usually the high calorific waste makes up less than 5% of the whole mass flow of a blast furnace. The blast furnace top gas is then co-incinerated together with other energy sources.

4.1.3. Monitoring and ELV

4.1.3.1. Control of PCB emissions

Issue

The Waste Incineration Directive provides requirements on the control of emissions of dioxins and furans (PCDD/Fs) but not on polychlorinated biphenyls (PCBs).

Short analysis

PCBs are classified as probable human carcinogens, producing a wide spectrum of adverse effects in animals, including reproductive toxicity, immunotoxicity and carcinogenicity. [COM 2001, BUWAL 2003]

The Air Quality Guide for Europe of the World Health Organisation (WHO) underlines the importance of controlling known sources as well as to identify new sources due to the potential importance of the indirect contribution of PCBs in air to total human exposure. [WHO 2000a]

The objectives of the Community Strategy on dioxins, furans and PCBs [COM 2001] are:

- to assess the current state of the environment and the ecosystem,
- to reduce human exposure to dioxins and PCBs in the short term and to maintain human exposure at safe levels in the medium to long term,
- to reduce environmental effects from dioxins and PCBs.

The WID does not include monitoring and measurement requirements for PCB and those substances are not reflected in the ELV for PCDD/F where only toxic equivalence factors for 17 PCDD/F are accounted for.

However, thermal processes including the incineration or co-incineration of waste are seen as a potential source of PCB emissions.

Uncertainty exists regarding the feasibility of including especially the dioxin-like PCB to the monitoring and control of PCDD/F in the framework of the WID.

4.1.3.2. Measurement requirements

Issue

Monitoring of parameters for which the ELV of the WID can not be exceeded (e.g. because the substance is not present in the waste) can lead to unnecessary costs.

Short analysis

The WID already allows reduced measurements in certain cases. It provides a variety of criteria to be applied for the assessment whether reduced monitoring efforts are justified. However, the possibilities for a reduction of monitoring efforts are restricted in Article 11 of the Directive. Depending e.g. on the composition of the waste that is incinerated or co-incinerated cases exist where further reduction of efforts can be justified beyond the given flexibility.

4.1.3.3. PCDD/F and heavy metals emission monitoring

Issue

Continuous measurement of PCDD/F and of heavy metals is treated in the WID as an emerging technique.

Short analysis

Article 11.13 of the WID says: “The Commission, …, 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.”

The technology for continuous monitoring of PCDD/F and heavy metals has been further developed in recent years and experience from their application in incineration and co-incineration plants exists.

4.1.3.4. NO_x ELV for existing cement kilns

Issue

The WID differentiates between existing and new cement kilns and assigns different ELV for the parameter NOx. Article 14 of the WID requires assessing (technically and economically) whether the NO_x-ELV for new cement kilns can be applied to existing cement kilns.

Short analysis

Technologies enabling reduced NOx emissions are available in principle.

4.1.3.5. Secondary steel industry

Issue

Some of the requirements of the WID do not fit well for the batch process in an electric arc furnace of the steel industry in which high calorific waste is used.

Short analysis

The co-incineration of waste in Electric Arc Furnace (EAF) leads to peaks of concentrations of substances such as heavy metals or organic substances in the off gas that are regulated by half hourly average values or daily average values in the WID. The concentration peaks occur at the beginning of the batch process for few minutes followed by a longer period of low concentrations. As the off gas from the oven is often mixed with air which is sucked from the oven area in order to prevent fugitive emissions, the oxygen concentration can not be used as a normalisation basis. In addition the “tap to tap” time of the batch process is too short to apply several time-related requirements of the WID (like e.g. monitoring or shutdown requirements).

According to the available information one plant in Europe is performing trials for the co-incineration of waste based on a WID permit.

Thus it can be concluded that this is mainly a specific technical issue with concerning very few plants.

4.1.3.6. Concluding remark

As shown the co-incineration of waste in secondary steel industry has a low mass relevance at the moment and is applied in a very low number of plants. The remaining issues highlighted in this section have elevated relevance and are further analysed in the following chapters:

- Measurement requirements: chapter 4.3
- Control of PCB emissions: chapter 4.4
- PCDD/F emission monitoring: chapter 4.4.2 and 4.5
- Heavy metal emission monitoring: chapter 4.6 and 4.7
- NOx emission levels: chapter 4.8 and 4.9

4.1.4. Other issues of interpretation

4.1.4.1. Small waste oil burners

Issue

The measurement requirements of the WID are difficult to apply from a technical viewpoint and would result in very high relative costs when waste oil is co-incinerated in small waste oil burners. Enforcement of the WID requirements for small waste oil burners has been described as very difficult.

Short analysis

The (co-)incineration of waste oil in small waste oil burners is not allowed in some Member States. In other Member States this is not seen as an operation which is in the scope of the WID. In one Member State an operator can apply for a WID permit but no one did so yet.

Small waste oil burners are technical units that usually do not have off gas abatement systems and devices for the measurement of emissions (and thus do not comply with the WID requirements).

According to the available information from the questionnaires (see chapter 2 and Annex to this report) the relevance of this operation in terms of overall mass relevance is small.

4.1.4.2. Thermal cleaning processes

Issue

Workpieces and tools are thermally cleaned in some industry sectors e.g. from overspray in paint lines or dipping processes. When the contaminations (paints, polymers) are burned the emissions could be similar to what is regulated by the WID.

There is uncertainty in some MS whether this operation falls under the WID.

Short analysis

´The workpieces as such or the tools are not waste, but contamination might be considered to be waste. The absolute amount of material actually burned in this kind of processes (e.g. the organic layer on a metal sheet, the organic contamination of a soil) seems to be very small.

4.1.4.3. Pyrolysis, gasification/ Definition

Issue

Pyrolysis/gasification is explicitly mentioned in the WID definition of incineration plant but not in the definition of co-incineration plant (WID Article 3.4). Practical implementation problems might result from the fact that the gas from pyrolysis plants is sometimes co-incinerated in installations with other owners or covered by other individual environmental permits.

Short analysis

A relatively low number of waste pyrolysis and gasification plants exist in Europe. They may treat different kinds of waste like municipal solid waste, biomass, wood waste or waste from production processes. They are often associated with power plants or cement kilns and are therefore rather part of co-incineration plants than incineration plants. However, the technical unit where the pyrolysis or gasification is performed (e.g. the pyrolysis kiln) is usually an installation dedicated to the thermal treatment of waste.

Member States reported that national transpositions of the WID are already applied to pyrolysis plants in spite of ambiguity of the definition in Article 3 of the Directive.

The overall mass relevance of remaining installations is estimated to be low.

4.1.4.4. Miscellaneous issues

Several points have been raised by the stakeholders where the provisions of the Directive are seen as unclear and/or not detailed enough. The following section summarises a number of such issues raised by the stakeholders.

- Some installations are co-incinerating waste just for a certain period of time e.g. when the specific waste is available. In the remaining operation time regular fuels are used. Clarification is required on whether the provisions of the WID for co-incineration plants always apply or only during those periods when waste is co-incinerated. No concrete proposal has been made by the stakeholders.

- Article 2.2 of the WID names plants that are excluded from the scope of the Directive. Paragraph (a) (iv) refers to plants that exclusively treat wood waste "with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood-preservatives or coating, and which includes in particular such wood waste originating from construction and demolition waste". Uncertainty exists about threshold values for concentrations of contaminants above which the WID is to be applied.
  In some Member States detailed regulations are applied that set those threshold values in a differentiated way (e.g. Germany, Austria, Belgium Flanders). In addition quality management systems are developed providing a range of quality categories for waste woods.
  Stakeholders proposed to take similar approaches for giving guidance for the application of the WID.

- Regarding the information management related to provisions of Article 8, 11, 12 and 13 of the WID stakeholders stated the need of a unified data structure and clearly defined forms. The background is that a reduction of administrative efforts for reporting and data management could be achieved in this way. According to the stakeholders this could be further improved by enabling electronic reporting procedures. (See also previous bullet point.)

- Similar ambiguity has been stated for radioactive waste according to Article 2.2(a)(vi) where it has been proposed that reference should be given to European legislation in order to provide threshold values for the determination when a waste is to be seen as radioactive.

- Article 5.4(b) of the WID requires taking of representative samples "to verify conformity with the information provided for in paragraph 3 by carrying out controls and to enable the competent authorities to identify the nature of the wastes treated". Stakeholders asked for detailed guidance regarding representative sampling in order to ensure harmonised procedures in all Member States.

- Concerns have been raised regarding cases where the commissioning phase of a plant is very long (cases have been described where the commissioning phase lasted up to 12 months. Stakeholders asked for rules on the monitoring requirements and ELVs during the commissioning period.

- Article 6, Article 11 and Annex V of the WID include specific requirements for the start up and shut down phase of incineration and co-incineration of wastes. Stakeholders raised the point that no clear guidance is available on when the start up phase ends and when the shut down phase starts and differences in the approaches of the Member States are feared. This is especially seen as a problem regarding the requirements of Article 6.3 (automatic system to prevent waste feed), in batch processes where waste is co-incinerated and where exemptions according to Article 6.4 of the WID are granted[108].

- Cases have been described by stakeholders where off gases from several incineration or co-incineration lines are merged before the off gas abatement installations. All lines co-incinerate different portions of waste and thus should have different ELV. In addition every single off gas stream has a different profile of concentrations of hazardous substances. In order to ensure a level playing field in the EU guidance was requested on how to set emission limit values in those cases.

- Article 6.3 of the WID requires that the incineration or co-incineration of waste shall be discontinued when the emission limit values are exceeded. The point was raised that indication is missing on how to apply this requirement to the two different time intervals of emission limit values of the Annex of the WID and the given confidence intervals.
  In article 13(4) it has been seen as unclear whether the dust ELV may be touched every half hour during the four-hour period, and it is unclear what CO and TOC values may not be exceeded.

- .The need for having general guidance for the application of the mixing rule was stressed mainly from companies that experience different approaches on how the mixing rule is handled in Member States where the have subsidiaries.

- In cases where no emission limit value C_{proc} is available for the calculations of the mixing rule this value must be determined as a reference value without co-incineration of waste. Guidance is seen as necessary by stakeholders not least in order to unburden local permitting authorities in the Member States.

[108] Specific requirements for the start up and shut down phase are related to combustion temperatures like e.g. Article 6.1 that requires the use of auxiliary burners when the temperature of the combustion gases after the last injection of combustion air falls below 850 °C or 1 100 °C. According to Article 6.4 exemptions from the obligation to achieve 850°C/110°C minimum temperature can be granted under certain circumstances.

- Annex II.1.2 of the WID says that: “Exemptions may be authorised by the competent authority in cases where TOC and SO_2 do not result from the incineration of waste.” Guidance for appropriate approaches on how to prove that these do not result from the incineration of waste has been stressed as missing by stakeholders.

- Regarding the provisions of Article 11.11 of the Directive stakeholders asked for clarification on how a valid “½ hour” could be defined (for example: “20 minutes of values” could be accepted where the CEM is off line for calibration/zero check purposes). It was stated that there is a need to clarify the position of calibration (“is calibration and zero-drift checking to be included in the disallowed values?”).

- Article 11.7 of the WID provides that the reduction of the frequency of the periodic measurements for heavy metals and for dioxins and furans may be authorised provided that certain criteria are met. It has been asked by stakeholders to give advice when those criteria will be available.

- It was requested to get clarification on the term “breakdown” in Article 13 (2).

- The text of Article 13 “Abnormal operation conditions” was described as hardly understandable.

- It was stated that in article 13(3) it is unclear which limit values shall form the basis for measuring excesses for the four-hour period, as the air emission limit values in annex V are either daily average values or half-hourly values.

- Article 13(3) refers to the 4-hour shut limitation on ceasing incineration during for abnormal operation. It was stressed that this can be met by most continuously fed incinerators but for batch plants such as gasification/pyrolysis units the batch cycle time can exceed 4 hours (in some cases the batch cycle can be as much as 18 hours).

- The interaction between Article 6 and 13 was described by stakeholders as unclear. In particular problems have been seen in defining what “cease feeding waste” might mean, for example in a mass-burn MWI where the feed chute is choke fed. At the point where the ELV is exceeded, there may be many tonnes of waste committed to be fed to the furnace. It was asked whether “cease feeding” means stop charging the final hopper. Paragraphs 1 and 3 appear to contradict each other, unless paragraph 3 is intended to set a limit on the Member State’s discretion allowed under paragraph 1. It was proposed that these two clauses should be amalgamated.

- Stakeholders raised the point that threshold criteria and/or values for relevance of the use of hazardous waste are sensible for the application of the provisions of Article 4.8.

- The existing provisions for exemptions from the requirements of Article 6.1 to Article 6.3 have been seen not detailed enough and it was stated that differences in the application of these requirements can be observed in Europe. In addition the requirements of Article 6.4 regarding the amount of residues have been described as not appropriate in cases where LCA-based assessments show that the environmental benefits are higher, when a higher amount is accepted.

4.1.4.5. Concluding remarks

In many cases the issues raised by the stakeholders require clarification of the existing provisions (e.g. by setting criteria for the application of provisions or exemptions). The rationale is, inter alia, to ensure the homogenous implementation of the Directive and a level playing field in the EU. Missing clarity of the Directive often also imposes the burden to develop criteria and thresholds to the local permitting authority without having sufficient guidance. In many cases those clarifications would not require (extensive) changes of the text of the Directive and can be in the form of guidance (e.g. via a European Guidance Document on the implementation of the WID).

4.2. Policy options analysed in this study

Based on the issues raised by the stakeholders (see chapter 4.1) and the analysis performed in the course of this study the following issues have been selected in close discussion with the Commission Services to execute a feasibility and/or impact assessment on the following issues:

- Impact analysis on allowing further exemptions from monitoring/measurement requirements (beyond current provisions) (see chapter 4.3)
- Technical feasibility of adding dioxin-like PCBs to the monitoring of PCDD/F (see chapter 4.4.1)
- Technical feasibility of continuous PCDD/F monitoring (see chapter 4.4.2) and the Analysis of impacts of continuous PCDD/F monitoring (see chapter 4.5)
- Technical feasibility of continuous heavy metal monitoring (see chapter 4.6) and the Analysis of impacts of introducing continuous monitoring of heavy metals (see chapter 4.7)
- Technical feasibility and costs of implementing a NOx emission limit value of 500 mg/m3 for existing cement kilns (see chapter 4.8) and the Analysis of impacts of reducing NOx emission limit values in existing cement plants (see chapter 4.9)
- Analysis of impacts of specific provisions regarding the use of high calorific waste in blast furnaces (see chapter 4.10)
- Specific provisions for the expanded clay industry (see chapter 4.11)

Regarding a potential "Impact analysis on the determination of emission limit values for the co-incineration of waste in lime kilns" no sufficient data have been made available by EULA providing evidence and details of the issue or example of affected plants. Thus no impact analysis has been possible. However, information provided by EULA about a proposal to set a Cproc value for lime kilns have been included in chapter 4.12.

All impact assessments have been done by following the Impact Assessment Guidelines of the Commission [COM Impacts 2005/2006].

For the impact assessment, the following steps have been undertaken:

- Identification of impact categories with possible relevance to the options;
- Screening the impacts to identify those applying to each stakeholder group (business, consumers, public authorities and the environment);
- Qualitative description of the impacts (e.g. on trade, competitiveness, administration);
- Quantification of the impacts (as far as data are available).

4.3. Impact analysis on allowing further exemptions from monitoring/measurement requirements (beyond current provisions)

4.3.1. Problem definition

The WID allows certain exemptions from the monitoring requirements regarding emissions to air for certain parameters in a way that discontinuous measurements are performed instead of continuous measurement and that the frequency of the measurements is reduced.

Stakeholders raised the point that measurement requirements may impose unnecessary burden on plant operators in certain cases and that further exemptions from these requirements are justifiable.

4.3.1.1. Monitoring requirements of the WID and possibilities for exemptions

The WID requires monitoring of emissions to air and water. Also, certain process operation parameters have to be monitored.

As regards air emissions, the WID requires measurements for all parameters where limit values for emissions are set (article 11(2)-11(12)). For all but 4 parameters exemptions are possible as shown in table below.

Table 69: Monitoring requirements of the WID for emissions to air and possible exemptions from monitoring requirements

Parameter	Measurement: Contin.	Measurement: Discontin.	Other provisions
NOx	X		(where ELV is set)
CO	X		
Dust	X		
TOC	X		
HCl	X	if the operator can prove that the emissions can under no circumstances be higher than the prescribed emission limit values: → two measurements per year	
HF	X		if treatment stages for HCl are used which ensure that the emission limit value for HCl is not being exceeded: →2 measurements per year
SO_2	X		
Heavy metals	-	two per year provided that the emissions are below 50 % of the emission limit values[109]: →1 measurement per 2 years	one measurement at least every three months for the first 12 months of operation
PCDD/F	-	Two per year provided that the emissions are below 50 % of the emission limit values[109]: →1 measurement per year	one measurement at least every three months for the first 12 months of operation
PAH	-		May be set by MS
Other	-		May be set by MS

Article 11.6 of the WID provides that continuous measurement of HCl, HF and SO_2 can be replaced by periodic measurement (2/year) "if the operator can prove that the emissions can under no circumstances be higher than the prescribed emission limit values".

For air emissions monitoring, article 11.7 of the WID mentions that a combination of criteria needs to be met for the reduction of the frequency of the periodic measurements of heavy metals and dioxins and furans:

- that 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
- criteria to be developed under a comitology procedure, to be based at least on the criteria mentioned below under (a) and (d).

Until 1 January 2005, the following criteria could be applied for the reduction of the periodic monitoring frequency of heavy metals and dioxins and furans:

(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;

[109] The WID also states: "and provided that criteria for the requirements to be met, developed in accordance with the procedure laid down in Article 17, are available." However, those criteria are not available and the transition period is over.

(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.

Table 70: Monitoring requirements of the WID regarding operation conditions and possible exemptions

	Contin.	
In combustion chamber		
Temperature	X	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[110]
Residence time		
Oxygen concentration of the exhaust gas	X	
In exhaust gases		
pressure	X	
temperature	X	
water vapour content	X	Not required if the sampled exhaust gas is dried before the emissions are analysed.

Table 71: Monitoring requirements of the WID for emissions to water (at the point of discharge)

Parameter	Contin.	Discontin.	Other provisions
pH	X		
temperature	X		
flow	X		
total suspended solids		spot sample daily measurements	alternatively provide for meas-urements of a flow proportional representative sample over a period of 24 hours
Hg, Cd, Tl, As, Pb, Cr, Cu, Ni, Zn		at least monthly measurements of a flow proportional representative sample of the discharge over a period of 24 hours	
PCDD/F		at least every six months measure-ments of dioxins and furans; one measurement at least every three months for the first 12 months of opera-tion	
PAH		may be fixed by MS	
Other		may be fixed by MS	

[110] Provisions in WID regarding verification of temperature and oxygen do not mean that the continuous measurements can be dropped.

4.3.1.2. Analysis of emission parameters of the WID

The following analysis focuses on measurement requirements related to air emissions. Measurement requirements related to emissions to water are not further considered with the background that first appraisals of relevance showed that exemptions from measurement requirements for water emissions would only be relevant for a very small number of plants[111] and that those requirements have not been mentioned by stakeholders.

Regarding measurement requirements related to operation conditions the existing text of the WID already allows that monitoring of residence time, minimum temperature and oxygen content in the combustion chamber is only performed once when “when the incineration or co-incineration plant is brought into service” [WID Article 11.3].With this background no further analysis of further exemptions is performed here.

The following text gives a short analysis of the air emission parameters of the WID and the elements that influence the level of emissions for these parameters.

The air emission parameters of the WID can be categorised roughly in three categories:

Category 1: Parameters where the substances are brought into the process via the waste and that are not destroyed or built in the process (example: heavy metals, SO_2, HCl or HF).

Category 2: Parameters where basic components are brought into the process via the waste and where substances are built and/or destroyed in the process. This is mainly valid for PCDD/F. For these emission parameters process characteristics play an important role regarding actual emission levels in addition to the input of certain substances/precursors via the waste (like chlorine and catalytic substances as well as the temperature profile for the formation of PCDD/F).

Category 3: Parameters where substances result from the process but that are not brought into the process via the waste to a significant proportion. (e.g. NO_x, TOC, CO).

[111] For dedicated waste incinerators the heterogeneity of the waste input and the relatively high uncertainty regarding its composition prohibits further exemptions. The predominant number of co-incineration plants in Europe and a high percentage of incineration plants have dry or at least semi-dry off gas abatement systems.

4.3.2. Policy options

The fundamental principle maintained regarding any further exemption is to keep the same level of environmental protection, while cutting unnecessary costs.

The following overview lists possible future exemptions from monitoring requirements of the WID that go beyond the existing exemptions and specifies criteria to evaluate the possibilities of having further exemptions requirements and/or conditions that must be fulfilled.

Table 72: Overview of options for monitoring exemptions (waste related criteria)

Parameter	**Further measurement exemption**	**Specific provisions**
Category 1		
All heavy metals	No measurements	If the emission limit values can not be exceeded even under the most unfavourable conditions because of low heavy metal concentrations in the waste [112] *Example: In a worst case consideration it is assumed that 100% of the substances of concern are evaporated in the thermal process and transferred into the off gas (transfer factor = 100%). The off gas volume resulting from the waste is calculated as it is done for the application of the mixing rule. It is also assumed that the concentration of the substances of concern in the off gas is not reduced by abatement systems.* Regarding heavy metals this approach is applied for Hg, Cd, Tl and Pb (being the most volatile HM). *Example: An emission limit value for lead of 0.5 mg/Nm^3 can not be exceeded even in the most unfavourable conditions when the lead concentration in an exemplary shredder light fraction is below 8 mg/kg (calculated theoretical air and combustion gas = 16 Nm^3/kg (dry) resulting in a maximum emission value of 0.5 mg/Nm^3 at 11%O_2). (Remark: Possible margins of uncertainty have to be taken into account).*
All heavy metals except mercury and eventually cadmium[113]	No measurements	If the waste related concentration values of the above case are exceeded but it can be proven that the emission values are at least 50% below the emission limit values whenever the dust emission is complying with the WID ELV, than "total dust" may be used as a "guidance parameter". When the ELV for dust is met it can be assumed that the heavy metals emission limits will also be met.
SO_2	No measurement	If the emission limit values can not be exceeded even under the most unfavourable conditions because of low sulphur concentrations in the waste.
HCl	No measurements	If the emission limit values can not be exceeded even under the most unfavourable conditions because of low chlorine concentration in the waste.
HF	No measurements	If the emission limit values can not be exceeded even under the most unfavourable conditions because of low fluorine concentration in the waste.

[112] It has to be taken into consideration when detailed requirements are developed that the amount of off gas depends inter alia on the portion of substances that can be oxidised (mostly carbon and hydrogen, but sometimes also sulphur as in the case of primary copper plants that use sulphured ores). This correlates often quite well with the lower calorific value of a waste. When for example two wastes are used that have the same concentration of heavy metals but different percentages of carbon and/or hydrogen, the concentrations of heavy metals in the off gas will be different

[113] A relevant portion of mercury and eventually cadmium in the off gas is not bound to dust particles but occurs in gaseous forms.

Table 73: Overview of options for monitoring exemptions (waste + process related criteria)

Parameter	Measurement exemption exceeding the exemptions already in the WID	Specific provisions
Category 2		
PCDD/F	No measurement after a number of measurements in the first months of operation	Exemption is possible if the concentration of halogens in the waste is low[114] and the process conditions ensure proper combustion (minimum combustion temperature and residence time), the design of the off gas abatement system minimises the potential of de novo synthesis, when specific dioxin abatement techniques are in place and can be checked, when dust emission values and off gas temperature is measured continuously. These criteria need to be developed further
HCl	See table category 1	
HF	No measurements after a number of measurements in the first months of operation	If treatment stages for HCl are used which ensure that the emission limit value for HCl is not being exceeded and if it is ensured that the portion of fluorine containing waste (e.g. textiles) does not require specific off gas abatement measures and when the parameter HCl is monitored
Dust	none	The parameter dust functions as a guiding parameter for the performance of the off gas abatement system. Other emissions are closely related to the parameter dust (heavy metals, PCDD/F). Thus, no further exemptions are taken up in the options for the impact assessment.

It is a prerequisite for exemptions to the measurements of the category 2 parameters PCDD/F and HF that appropriate waste quality assurance is in place.

Table 74: Overview of options for monitoring exemptions (process related criteria)

Parameter	Measurement exemption	Specific provisions
Category 3		
NOx, TOC, CO	none	The parameters NOx, CO and TOC are parameters that are little influenced by the incinerated or co-incinerated waste but mainly by the combustion conditions and are indicators for the process performance.

4.3.3. Identification of priority impact categories

Screening possible impact categories with regard to economic impacts incidence of the impact categories competitiveness, trade and investment flows, operating costs and conduct of business, administrative costs on businesses and public authorities are expected. Economic impact might differ depending on the industry sector affected. Because impacts in the internal market are not expected to be significant, this, in turn, will entail limited impacts under the impact categories property rights, innovation and research, consumers and households, specific regions, third countries and international relations and the macroeconomic environment.

[114] No sufficient data basis is available for the determination of concrete values at the moment.

Relevant environmental impact categories are air quality and the likelihood or scale of environmental risks and potentially water quality where wet off gas cleaning systems are in place for affected parameters. Limited impacts are expected regarding soil quality or resources, climate, renewable or non-renewable resources, biodiversity, flora, fauna and landscapes, land use, waste production /generation / recovery mobility (transport modes) and the use of energy, the environmental consequences of firms' activities as understood in the impact assessment guidelines SEC(2005) 791 and animal and plant health, food and feed safety.

Regarding social impacts no or minor impacts are expected for the categories standards and rights related to job quality, social inclusion and protection of particular groups, equality of treatment and opportunities, non –discrimination, private and family life, personal data, governance, participation, good administration, access to justice, media and ethics, crime, terrorism and security and access to and effects on social protection, health and educational systems. Impacts are possible regarding the categories public confidence in the incineration and co-incineration of waste, employment and labour markets. The category public health is considered together with environmental aspects.

4.3.4. Impact analysis

4.3.4.1. Appraisal of the number of affected installations

According to the data that became available during data collection 1444 incineration and co-incineration plants were identified in total. The largest group are dedicated waste incinerators (40%) followed by combustion plants (15%) and cement plants (10%) but for many plants (27%) no information on the process was available. Taking into account that some stakeholders did not deliver information and concluding from expert interviews and literature research it is estimated that a total of 1800 plants incinerate or co-incinerate waste in Europe[115].

Comprehensive data about the composition of incinerated and co-incinerated wastes which would enable a precise determination of the number of plants that potentially qualify for further exemptions are not available. In this section a number of qualitative or semi quantitative methodological approaches are applied in order to narrow the number of plants that could potentially qualify for further exemptions from monitoring requirements.

In a first step the number of existing exemptions according to the present WID has been evaluated. In total 982 exemptions from measurement requirements have been reported (see chapter 2 of this report). 498 granted exemptions for HF measurements according to Article 11(6) have been reported, 248 exemptions for HCl measurements and 180 exemptions for SO_2. Exemptions for measurements of Hg and Cd+Tl according to Article 11 of the WID have been

[115] It has to be taken into consideration that some data uncertainty exists, see chapter 2 of this study.

reported 13 times and exemptions for sum of heavy metals and PCDD/F 15 times.

Taking into account the percentage of stakeholders that answered the questionnaires and/or have been available for phone interviews or meetings it is estimated that the number of exemptions is higher than shown in this picture.

The following table summarises the results from the data collection of task 1 and includes an appraisal of potential underestimations of number of plants permitted under the WID and number of exemptions.

Table 75: Quality of data available on the number of incineration and co-incineration plants and on permitted exemptions from measurement requirements

		Dedicated waste incinerators	Cement kilns	Combustion plants	Lime kilns	Non Ferrous metals plants	Ferrous metals plants	Expanded clay kilns	Chemical industry	Pulp & paper	Wood	Fertiliser	Food	Rendering plants
No of plants with WID permit	Data quality (completeness of data)	Average	Good	Average	Average	Average	Good	Good	Poor	Good	Poor	Poor	Poor	Poor
	Data basis (number of sources)	6 MS, 2 EU Associations, expert interviews	19 MS, 1 EU association, expert interviews	12 MS	4 MS 1 EU association	3 MS, expert interviews	1 MS, 1 EU association, expert interviews	4 MS, 1 EU association	3 MS,	4 MS, 1 EU association	2 MS	1 MS	1 MS	Expert info
Permitting	Completeness of identified plants that incinerate or co-incinerate waste	High	High	High	Medium	Medium	High	High	Low	Medium	Low	Low	Low	Low
Potential for underestimations	… of number of permits	Medium	Low	Medium	Low	Medium	Low	Low	High	Medium	High	High	High	Low
	… of existing exemptions	Medium - high	Low	High	Medium	High	High	High	High	Medium	High	High	High	High

Based on the above considerations the following assumptions and numbers of existing exemptions from monitoring requirements are taken as a basis for the impact assessment:

- The actual number of incineration and co-incineration plants is 20% higher than shown in the data from questionnaires and interviews.
- Exemptions regarding HCl are permitted in 25%, for HF in 51% and SO_2 in 18% of the relevant cases.
- In 1% exemptions regarding heavy metals and PCDD/F measurements are permitted.

The number of unreported exemptions for heavy metals and PCDD/F is estimated lower than the number of unreported exemptions for HCl, HF, and SO_2 because it is expected that a lower percentage of plants qualify for exemptions from heavy metal and PCDD/F measurement requirements. The percentage of HCl, HF and SO_2 exemption in the estimated total number of exemptions is assumed 50% higher than in the results from data collection because regarding the "total number of plants" the data quality was better and the number of answers was higher compared to the "granted exemptions" (see chapter 2 and Table 75).

Table 76: Existing exemptions from measurement requirements

	Result from data collection in task 1		Estimated total number	
	Number	%	Number	%
Total number of plants	1444	100%	1800	100%
Total number of exemptions	982	68%	1260	70%
Measurement exemptions for HF	498	34%	918	51%
Measurement exemptions for HCl	248	17%	450	25%
Measurement exemptions for SO_2	180	12%	324	18%
Measurement exemptions for Hg	13	1%	18	1%
Measurement exemptions for Cd+Tl	13	1%	18	1%
Measurement exemptions for heavy metals	15	1%	18	1%
Measurement exemptions for PCDD/F	15	1%	18	1%

In a next step information about the composition of incinerated and co-incinerated waste has been evaluated regarding the question which percentage of incinerated and co-incinerated waste potentially fulfils the requirements for further exemptions for parameters under category 1 and 2.

One approach taken was to analyse information about wastes where the composition could qualify in principle for further exemptions ("**positive determination**") e.g. certain wastes from food industry which are low in contaminations. Stakeholders mentioned the following waste types that are incinerated or co-incinerated in Europe and that might qualify the plant for further exemptions:

Table 77: Wastes incinerated or co-incinerated in Europe that are low in contaminations of parameters of category 1 (examples)

EWL code (5 digit level)	EWL text
20102	animal-tissue waste
20103	plant-tissue waste
20106	animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site
20107	wastes from forestry
20109	agrochemical waste other than those mentioned in 020108
20202	animal-tissue waste
20203	materials unsuitable for consumption or processing
20301	sludges from washing, cleaning, peeling, centrifuging and separation
20304	materials unsuitable for consumption or processing
20601	materials unsuitable for consumption or processing
20701	wastes from washing, cleaning and mechanical reduction of raw materials
30301	waste bark and wood

Recent EUROSTAT waste statistics and the newly available waste statistics based on EWCStat do not provide the degree of detail for this “positive determination” [EUROSTAT 2007]. Other waste stream specific data sources have been evaluated like [ECOLAS 2007] about tallow.

Most of the mass relevant waste streams that could qualify for the “positive determination” are excluded from the scope of the WID according to Article 2.2(a) (i)-(iv).

In a “**negative determination**” it was analysed which waste streams show compositions that disqualify for further monitoring exemptions:

- It can be assumed that for most dedicated waste incinerators for mixed wastes and for hazardous wastes (total number of plants: 677) the requirements for further exemptions for parameters of the category 1 and 2 are not fulfilled because of the varying waste composition and high degree of uncertainty regarding the composition of the waste.
- In a number of cement plants with WID permits a variety of waste is co-incinerated and economic considerations (waste price, availability of the waste, market position for acquiring waste) will determine that not exclusively wastes are used that are very low in contaminations of category 1 parameters (total number of cement plants: 194).

- For a number of power plants it is planned that quality assured solid recovered fuels will be co-incinerated. In principal incineration or co-incineration of those wastes could qualify for further monitoring exemptions. However, the CEN standard for solid recovered fuel which is presently under development includes in its current version (for details see description of draft specifications and classes in Annex 3 to this report) only concentration limits for mercury. Other parameters of category 1 are not restricted. Other similar standards on European level do not exist (total number of combustion plants: 253).

In a third step requirements resulting from other materials used in the thermal processes like raw materials and primary fuels have been considered. The input of substances of concern into the cement process via raw materials and primary fuels is in most of the known cases in a range that makes it unlikely that those processes could qualify for further exemptions regarding category 1 parameters. Same is valid regarding the chlorine input. For the parameter HF a low number of cases are expected where the requirements of category 2 parameters are fulfilled[116]. For combustion plants further exemptions are conceivable in cases where low contaminated biomass (like waste wood or waste from livestock) is burned as primary fuels and where other burned wastes show low contamination rates.

Because of the high data uncertainty regarding the composition of incinerated and co-incinerated waste two scenarios have been developed with different assumptions in order to cover the expected range of the number of potentially affected plants. In scenario 1 a relatively high number of plants qualify for further exemptions (beyond current provisions) from measurements requirements, in scenario 2 a lower number qualifies.

Table 78: Scenarios on the number of further exemptions

	Scenario 1 "High number"		Scenario 2 "Low number"	
	Number	%	Number	%
Total number of plants	1800	100%	1800	100%
Measurement exemptions for HF	500	27,8%	200	11,1%
Measurement exemptions for HCl	300	16,7%	100	5,6%
Measurement exemptions for SO2	200	11,1%	70	3,9%
Measurement exemptions for Hg	20	1,1%	10	0,6%
Measurement exemptions for Cd+Tl	20	1,1%	10	0,6%
Measurement exemptions for heavy metals	20	1,1%	10	0,6%
Measurement exemptions for PCDD/F	20	1,1%	10	0,6%

116 The chlorine input is limited in most of the cement kilns that co-incinerate waste by technical requirements. No specific HCl treatment stage is in place in most of the plants. However, usually the fluoride concentration in raw materials and primary fuels used in the cement industry is low.

For both scenarios it is assumed that in 80% of the plants that are qualified for further exemptions existing exemptions of the WID are already applied. In the remaining 20% no exemptions are applied yet.

As an additional aspect regarding the quantification of affected installations it will be considered that in some cases it will be possible to combine further developed measurement requirements and further exemptions. This is conceivable for continuous measurement of mercury and dust and the exemption that no additional heavy metal monitoring is required (see section 4.3.2).

4.3.4.2. Analysis of impacts

The following table gives an overview of the expected impacts of the proposed options relative to the baseline scenario where no further exemptions from measurement requirements are allowed.

Economic impacts	
Investment costs	Low difference in investment costs because in most of the cases the further exemption replaces discontinuous measurements, where no investment costs are necessary for the plant operator
Operating costs	Reduced costs compared to baseline because no measurements must be performed
Administrative costs on businesses	Reduced administrative efforts for monitoring and reporting
Administrative burden for public authorities	Reduced administrative efforts for monitoring
Impacts on the internal market	No differences of effects expected
Innovation and research	No differences of effects expected
Specific sectors	The positive effect of reduced costs for measurement on SME will be higher than for large enterprises because the required type or number of measurements is not differentiated by capacity of the plant. Thus plants of all sizes must fulfil the same measurement requirements.
The macroeconomic environment	No differences of effects expected
Environmental impacts	
Air quality	(see below, category “risk”)
Water quality and resources	No differences expected
Waste production / generation /recycling	No differences expected
The likelihood or scale of environmental risks	Slightly increased risk of emissions that are not monitored
The environmental consequences of firms’ activities	No effects expected
Social impacts	
Employment and labour market	Fewer measurements will have an effect on service companies performing measurements and on laboratories. A positive effect will be triggered for companies incinerating or co-incinerating waste resulting from less costs and therefore safer work place conditions.

4.3.4.3. Economic impacts

For the calculation of economic impacts the following costs figures and basic assumptions are applied[117]:

- HF, HCl, SO_2 continuous measurement: 20 000 € invest over 10 years and interest rates of 4%; operating costs of 1 000 € per year
- HF, HCl, SO_2 discontinuous measurement 750 €/measurement (no investments are necessary for discontinuous measurements)
- Measurement of heavy metals: 2 000 € per measurement[118] (no investments are necessary for periodic measurements). Analytic costs are 100 € per analysis (included in the total measurement costs of 2 000€) (see also explanations of the calculation below).
- Measurement of PCDD/F: 3 500 € per measurement (no investments are necessary for periodic measurements)

Measurements of HCl, HF and SO_2 can be combined in several cases resulting in lower overall measurement costs.

In the scenario with low number of further exemptions the following additional settings are applied:

- Exemptions for HF and HCl are combined in the same plants in all cases. This means that where further exemptions for both of these parameters are applied they have been measured before together. The resulting reduction of costs from further exemptions is thus lower than if the measurements have not been combined.
- Exemptions for HCl/HF and SO_2 are combined in 25% of the plants.

In the scenario with high number of further exemptions this possibility for combination is not taken into account in the calculation in order to show scenarios with a high spread of costs.

Measurements of heavy metals (Hg, Cd+Tl, Sum of HM) can be combined as well if measured in the same plant, but this is not necessarily the case. Therefore, two sub-scenarios have been calculated. In the first sub-scenario ("high measurement costs") the measurements are not combined and the full costs have been accounted. In the second sub-scenario ("low measurement costs") the exemption are granted for the same plants and the measurements can be combined. Thus, here only the analytical costs are accounted.

117 data on invest costs and costs for single measurements according to [ECOLAS 2007]

118 The measurement of different HM can be combined (e.g. parameters "Cd+Tl" and "Sum of Heavy Metals")

The following tables summarise the calculation of resulting costs for the parameters HCl, HF, SO_2, Hg, Cd+Tl, sum of heavy metals and PCDD/F.

Table 79: Scenario High number of exemptions – parameters HCl, HF, SO_2

Scenario: High number of exemptions				
Parameter		**HCl**	**HF**	**SO_2**
number of plants from discontinuous to no measurement (80%)	#	240	400	160
number of plants from continuous to no measurement (20%)	#	60	100	40
costs for discontinuous measurement	EUR/ measurement	750	750	750
Investment costs for continuous measurement	EUR	20.000	20.000	20.000
Depreciation of equipment for continuous measurement	years	10	10	10
Interest rate for equipment for continuous measurement	%/y	4	4	4
Operational costs for continuous measurement	% of invest	5	5	5
Costs for continuous measurement	EUR/Year	3.080	3.080	3.080
saved costs for discontinuous to no measurement	EUR	180.000	300.000	120.000
number of discontinuous measurements per year	#	2	2	2
Total saved costs for discontinuous to no measurement	EUR/y	360.000	600.000	240.000
Total saved costs for continuous to no measurement	EUR/y	184.800	308.000	123.200
Overall saved costs	**EUR/y**	**544.800**	**908.000**	**363.200**
Total saved cost	**EUR/y**	**1.816.000**		

Table 80: Scenario High number of exemptions – parameters Hg, Cd+Tl, Sum of heavy metals, PCDD/F

	Parameter	Hg	Cd+Tl	SumHM	PCDD/F
Sub-scenario: High number of exemptions + high measurement costs					
Number of plants qualifying for further exemptions from measurement requirements	#	20	20	20	20
Costs for discontinuous measurement	EUR/ measurement	2000	2000	2000	3500
Cases without exemption according to Article 11.7 (20%)	#	4	4	4	4
Cases with exemption according to Article 11.7 (80%)	#	16	16	16	16
Saved costs for installations without exemption according to Article 11.7	EUR/plant	4000	4000	4000	7000
Saved costs for installations with exemption according to Article 11.7	EUR/plant	1000	1000	1000	3500
Total saved costs for discontinuous to no measurement	EUR/y	32.000	32.000	32.000	84.000
Total saved cost	**EUR/y**	**180.000**			
Sub-scenario: High number of exemptions + low measurement costs					
Number of plants qualifying for further exemptions from measurement requirements	#	20	20	20	20
Costs for discontinuous measurement	EUR/ measurement	100	100	2000	3500
Cases without exemption according to Article 11.7 (20%)	#	4	4	4	4
Cases with exemption according to Article 11.7 (80%)	#	16	16	16	16
Saved costs for installations without exemption according to Article 11.7	EUR/plant	200	200	4000	7000
Saved costs for installations with exemption according to Article 11.7	EUR/plant	50	50	1000	3500
Total saved costs for discontinuous to no measurement	EUR/y	1.600	1.600	32.000	84.000
Total saved cost	**EUR/y**	**119.200**			

Table 81: Scenario Low number of exemptions – parameters HCl, HF, SO_2

		Parameter		
		HCl	HF	SO_2
Number of cases from discontinuous to no measurement (80%)	#	80	160	56
Number of cases from continuous to no measurement (20%)	#	20	40	14
costs for discontinuous measurement	EUR/ measure-ment	750	750	750
Invest costs for continuous measurement	EUR	20.000	20.000	20.000
Use time of equipment for continuous measurement	years	10	10	10
Interest rate for equipment for continuous measurement	%/y	4	4	4
Operational costs for continuous measurement	% of invest	5	5	5
Costs for continuous measurement	EUR/Year	3.080	3.080	3.080
HCl and HF measurements combined (100% combined) (discontinuous to no measurement)	number of cases	80		
HCl and HF measurements combined (100% combined) - remaining number of measurements for cost calculation (discontinuous to no measurement)	number of cases	0	80	/
HCl/HF/SO2 measurements combined (25% combined) (discontinuous to no measurement)	number of cases			14
HCl/HF/SO2 measurements combined (25% combined) - remaining number of measurements for cost calculation (discontinuous to no measurement)	number of cases	/	/	42
saved costs for discontinuous to no measurement	EUR	120.000		31.500
number of discontinuous measurements per year	#	2		2
Total saved costs for discontinuous to no measurement	EUR/y	240.000		63.000
Total saved costs for continuous to no measurement	EUR/y	61.600	123.200	43.120
Total saved cost	**EUR/y**	**530.920**		

Table 82: Scenario Low number of exemptions – parameters Hg, Cd+Tl, Sum of heavy metals, PCDD/F

	Parameter	Hg	Cd+Tl	SumHM	PCDD/F
Sub-scenario: Low number of exemptions + high measurement costs					
number of plants qualifying for further exemptions from measurement requirements		10	10	10	10
costs for discontinuous measurement	EUR/ measurement	2000	2000	2000	3500
plants without exemption according to Article 11.7 (20%)	#	2	2	2	2
plants with exemption according to Article 11.7 (80%)	#	8	8	8	8
saved costs for installations without exemption according to Article 11.7	EUR/plant	4000	4000	4000	7000
saved costs for installations with exemption according to Article 11.7	EUR/plant	1000	1000	1000	3500
Total saved costs for discontinuous to no measurement	EUR/y	16.000	16.000	16.000	42.000
Total saved cost	**EUR/y**	**90.000**			
Sub-scenario: Low number of exemptions + low measurement costs					
number of plants qualifying for further exemptions from measurement requirements	#	10	10	10	10
costs for discontinuous measurement	EUR/ measurement	100	100	2000	3500
plants without exemption according to Article 11.7 (20%)	#	2	2	2	2
plants with exemption according to Article 11.7 (80%)	#	8	8	8	8
saved costs for installations without exemption according to Article 11.7	EUR/plant	200	200	4000	7000
saved costs for installations with exemption according to Article 11.7	EUR/plant	50	50	1000	3500
Total saved costs for discontinuous to no measurement	EUR/y	800	800	16.000	42.000
Total saved cost	**EUR/y**	**59.600**			

The scenarios show potentials for cost savings in the range from 590 000 €/y to 2 million €/y[119].. Depending on the criteria applied for granting further exemptions additional costs for assessment of compliance with such criteria (e.g. analysis of waste) might reduce the overall cost savings.

The cost savings will reduce the overall process costs and thus improves in principle the competitive position of EU firms with their non-EU competitors. Advantages will result especially for SME where the specific costs of measurement per product unit are higher than for large companies. Same is valid for plants where a small percentage of energy needed for the process is provided by waste but where the full measurement program is required by the present text of the WID. Reduced costs might have a positive effect regarding the category "employment and labour markets". However, the relatively low cost savings

[119] It has to be taken into account that the level of uncertainty for these calculations is high regarding the number of affected plants and/or the number of possible further exemptions from monitoring requirements.

compared to the overall turnover of the waste incineration and co-incineration installations of around 6 billion EUR per year[120] makes significant effect unlikely.

4.3.4.4. Environmental impacts

When no measurements of concentration of pollutants in the off gas are performed there is an increased risk that the ELV are exceeded without noticing it.

For the appraisal of the magnitude of this risk compared to the baseline scenario it has to be taken into account that already the discontinuous measurements as they are required by the WID at the moment have relatively low probability to detect exceedances of ELVs.

An example is the measurement requirement of the WID for heavy metals where two measurements per year must be performed and exemptions could be granted reducing the frequency to one measurement per two years. Each measurement period is according to Annex V of the WID as an example 8 hours as a maximum and 30 minutes as a minimum. For dedicated waste incinerators an average operating time per year of 7800 hours is achieved in most of the plants. The time covered by heavy metal monitoring as required in the baseline scenario makes 0.2% as a maximum and below 0.01% as a minimum of the yearly operating hours. These measurements will reveal principal problems with the waste incineration or co-incineration and the off gas abatement system. At the same time the WID does not combine exemptions with additional requirements like specific quality assurance systems for the input waste.

In summary there is low additional risk of exceeding the ELV compared to the baseline scenario regarding parameters where the WID requires/ allows discontinuous measurements. However, the prerequisite must be fulfilled that criteria are applied, which should ensure that further exemptions from monitoring requirements are exclusively granted where chances of exceedance of ELV are very low (see chapter 4.3.2).

4.3.4.5. Sub-option: combined measurement requirements

A further option for amending the monitoring requirements of the WID is the combination of dust and mercury monitoring. In this option no additional heavy metal monitoring is required when the two parameters dust + Hg are monitored continuously. Background of this option is the fact that the heavy metals which are monitored by the present text of the WID (excluding mercury) are bound to dust to a high percentage at the stage of emission at stack and the relation between gaseous and particulate bound heavy metals show a stable picture as long as specific parameters in the off gas are not changed[121].

This option is in principal applicable to all incineration and co-incineration processes that show stable combustion and off gas conditions.

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[120] This is a rough estimation based on the amount of waste incinerated in dedicated waste incinerators (~60 million) with an average gate fee of 90 EUR per tonne and 15 million tonnes of co-incinerated waste with a gate fee of 40 EUR per tonne.

[121] E.g. the temperature

Economic impacts

The following table summarises the economic impacts of this sub-scenario. It includes again two scenarios: In the first scenario a high number of plants (50%) qualifies for this requirement, in the second scenario a low number (20%) qualifies. The basic costs for measurements are the same as in the main option. However, in order to get a view on possible range of results the number of existing exemptions according to Article 11.7 of the WID in the second scenario is higher than in the first scenario (resulting in reduced cost savings).

Table 83: Sub-option: Combination of measurement requirements and options

High number of exemptions + high measurement costs ((assuming Hg, Cd/Tl and other HM measurements are not combined)		
Number of cases which perform combined dust/Hg measurement	#	900
Number of cases with exemptions according to Article 11.7 WID	#	18
Number of cases without exemptions according to Article 11.7 WID	#	882
cost for continuous Hg measurement	EUR/ plant/ year	10.000
cost for heavy metal measurement without exemption according to Article 11.7 WID	EUR/ plant/ year	12.000
cost for heavy metal measurement with exemption according to Article 11.7 WID	#	3.750
Total cost savings	**EUR/y**	**1.651.500**

Low number of exemptions + low measurement costs (assuming Hg, Cd/Tl and other HM measurements are combined in 50% of the cases)		
Number of cases which perform combined dust/Hg measurement	#	360
Number of cases with exemptions according to Article 11.7 WID	#	18
Number of cases without exemptions according to Article 11.7 WID	#	342
cost for continuous Hg measurement	EUR/ plant/ year	10.000
cost for heavy metal measurement without exemption according to Article 11.7 WID	EUR/ plant/ year	4.200
cost for heavy metal measurement with exemption according to Article 11.7 WID	#	1.100
Total increase of costs	**EUR/y**	**2.143.800**

Cost effects from combined continuous measurement of dust + Hg plus exemptions from measurement of other heavy metals range from cost savings of ~1.6 million €/y to additional costs of 2.1 million €/y depending on the number of cases where continuous measurement is realised and the costs per discontinuous measurement of other heavy metals.

Economic advantages will only result where measurements can not be combined for different heavy metals and where no exemption according to Article 11.7 of the WID are granted.

Environmental impacts

The increased overall risk from non application of heavy metal monitoring other than mercury is determined by the fact that only plants should be seen as qualified where the process conditions are stable. In these cases the additional environmental risk would be low. At the same time the environmental risk will be reduced for the parameter mercury where otherwise no continuous monitoring of mercury emission would be performed.

4.3.5. Comparison of options

The analysis shows potentials for cost savings via further exemptions from monitoring requirements in the range from 590 000 €/y and 2 million €/y compared to the BAU scenario[122]. The related environmental risk from non performance of monitoring measurements is expected to be low.

The relative cost savings are not very high for the whole European incineration and co-incineration industry with around 1800 installations and a turnover of around 6 billion EUR per year[123]. The reason is, inter alia, that the potential for exemptions which exist in the present text of the WID is already utilised to a large extent and that further exemptions result in relatively low cost savings per qualified plant (e.g. no measurement of Cd+Tl instead of one measurement per two years).

Combining measurement requirements (continuous measurement of dust and Hg) and enable exemptions for other parameters at the same time (no measurement of the parameters Cd+Tl and Sum of HM where appropriate) could result in cost savings. This is especially the case, where costs for measurement of heavy metals are high (e.g. because different heavy metal measurements can not be combined and individual measurements must be performed).

Further exemptions from monitoring requirements might become sensible especially when other options as proposed in this study are realised. This includes for example exemptions from monitoring requirements when high calorific wastes are used in blast furnaces (see chapter 4.10) or in the context of the consideration of dioxin like PCB.

122 It has to be taken into account that the level of uncertainty for these calculations is high regarding the number of affected plants and/or the number of possible further exemptions from monitoring requirements.

123 This is a rough estimation based on the amount of waste incinerated in dedicated waste incinerators (~60 million) with an average gate fee of 90 EUR per tonne and 15 million tonnes of co-incinerated waste with a gate fee of 40 EUR per tonne.

4.4. Technical feasibility of PCB and PCDD/F monitoring

4.4.1. Technical feasibility of adding dioxin-like PCBs to the monitoring of PCDD/F

4.4.1.1. Introduction

The Waste Incineration Directive 2000/76/EC provides requirements on the control of dioxins and furans (PCDD/Fs), however not on polychlorinated biphenyls (PCBs). This chapter assesses the feasibility of adding dioxin-like PCBs to the WID monitoring requirements on PCDD/Fs.

Dioxins and furans are defined by Article 3 of the WID. Reference is made to Annex I which provides a list of PCDD/Fs. This list defines toxic equivalence factors for each substance (see table below).

For the calculation of the total concentration of PCDD/Fs, the toxic equivalence factors have to be multiplied with the detected amounts of each substance before summing up the results for each substance. The sum parameter is relevant for compliance check with emission limit value for PCDD/Fs of 0.1 ng TEQ/m^3.

Table 84: International Toxic Equivalence Factors (I-TEF) listed in Annex I of the Waste Incineration Directive

Dibenzo-p-dioxins	**TEF**	**Dibenzofurans**	**TEF**
2,3,7,8 Tetrachlorodibenzodioxin (TCDD)	1	2,3,7,8 Tetrachlorodibenzofuran (TCDF)	0.1
1,2,3,7,8 Pentachlorodibenzodioxin (PeCDD)	0.5	2,3,4,7,8 Pentachlorodibenzofuran (PeCDF)	0.5
1,2,3,4,7,8 Hexachlorodibenzodioxin (HxCDD)	0.1	1,2,3,7,8 Pentachlorodibenzofuran (PeCDF)	0.05
1,2,3,6,7,8 Hexachlorodibenzodioxin (HxCDD)	0.1	1,2,3,4,7,8 Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,7,8,9 Hexachlorodibenzodioxin (HxCDD)	0.1	1,2,3,6,7,8 Hexachlorodibenzofuran (HxCDF)	0.1
1,2,3,4,6,7,8 Heptachlorodibenzodioxin (HpCDD)	0.01	1,2,3,7,8,9 Hexachlorodibenzofuran (HxCDF)	0.1
Octachlorodibenzodioxin (OCDD)	0.001	2,3,4,6,7,8 Hexachlorodibenzofuran (HxCDF)	0.1
		1,2,3,4,6,7,8 Heptachlorodibenzofuran (HpCDF)	0.01
		1,2,3,4,7,8,9 Heptachlorodibenzofuran (HpCDF)	0.01
		Octachlorodibenzofuran (OCDF)	0.001

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are two groups of similar chlorinated ethers consisting not only of the 17 substances listed in the Waste Incineration Directive but of a total of 210 substances.

Polychlorinated Biphenyls (PCBs) belong to the group of aromatic hydrocarbons. As well as PCDDs and PCDFs, PCBs are considered as persistent substances because destruction in the environment was observed only for very few of the total of 209 PCB congeners. [LfU 2003]

The Community strategy for PCDD/Fs and PCBs gives special attention among the PCBs to a group of so called "dioxin-like PCBs" which exhibit dioxin-like toxicity. [COM 2001]

The Strategy describes PCDD/F and PCBs as a group of toxic and persistent chemicals effecting on human health and on the environment by dermal toxicity, immunotoxicity, reproductive effects and teratogenicity, endocrine disrupting effects and carcinogenicity.[124]

Although during the last 15 years the exposure with PCDDs and PCDFs has decreased in many countries, the average total daily intake rate by food remained at a level of about 1.2 – 3 pg TEQ per kilogram of body weight in EU 15.

Average ambient air concentrations of PCBs are estimated to be 3 ng/m^3 in urban areas. Although this air concentration is regarded only as a minor contributor to direct human exposure (about 1-2 % of the daily intake from food), it is seen as a major contributor to contamination of the food chain. [WHO 2000a]

The Air Quality Guide for Europe of the World Health Organisation (WHO) underlines the importance of controlling known sources as well as to identify new sources due to the potential importance of the indirect contribution of PCBs in air to total human exposure. [WHO 2000a]

The WHO defined in 1998 a tolerable daily intake of 1 - 4 pg TEQ/kg body weight (including dioxin-like PCBs), meaning that a large part of European citizens is currently exceeding the tolerable daily intake value. [LfU 2002]

The objectives of the Community Strategy on dioxins, furans and PCBs [COM 2001] are:

- to assess the current state of the environment and the ecosystem,
- to reduce human exposure to dioxins and PCBs in the short term and to maintain human exposure at safe levels in the medium to long term,
- to reduce environmental effects from dioxins and PCBs.

[124] "An increase in the presence in the environment of these substances coupled with several accidents (Yusho (Japan), Yu-cheng (Taiwan), Seveso (Italy), Belgium) have triggered a deep concern from the international community for their reduction and control. Moreover, there is considerable public, scientific and regulatory concern over the negative effects on human health and on the environment of long-term exposure to even the smallest amounts of dioxins and PCBs."

The Strategy aims at a reduction of the human intake levels of dioxins and dioxin-like PCBs below 14 pg TEQ per kilogramme bodyweight per week (TWI). This limit was established by the Scientific Committee on Food (SCF) of the EU in 2001, based on a risk assessment of dioxins and dioxin-like PCBs in food [COM SCF 2001. It is concurring with the lower end of the tolerable daily intake of 1 – 4 pg TEQ/kg body weight (TDI) established by WHO [WHO 1998].

4.4.1.2. Toxic equivalence factors for dioxin-like PCBs

The list of Toxic Equivalence Factors (TEF) included in the Waste Incineration Directive 2000/76 is based on WHO recommendations of the late 80s, based on the results of the research group NATO-CCMS determining toxicity equivalence of 17 out of 210 PCDD/Fs. The group of equivalence factors is called "International Toxic Equivalence Factors" (I-TEQ).

The I-TEQ system uses the toxicity of 2,3,7,8-Tetrachlorodibenzodioxin as reference (toxicity factor = 1). The toxicity of all other components refers as a relative value to the toxicity of this substance (toxic equivalence).

The toxic effects are evaluated by sub-chronic toxicity studies as well as by certain bio-chemical properties as the capacity to combine with Ah receptors. All other congeners detected in the sample are defined with a TEQ of zero.

Since 1994, WHO has recommended toxicity equivalence factors for some of the dioxin-like PCBs. [WHO 1994] The proposal is based on the assumption that PCDD/Fs and dioxin-like PCBs produce effects with the same mechanism. Also the Dutch Health Council proposed the application of toxic equivalence factors for dioxin-like PCBs in 1996. A concept of toxic equivalence factors for PCDD/F and dioxin-like PCBs was elaborated by the World Health Organisation in 1998. [WHO 2000b] The concept includes toxic equivalence factors for the 17 dioxins and furans (listed in the Waste Incineration Directive Annex I) and includes 12 dioxin-like PCBs. In this concept the toxic equivalence factors of NATO-CCMS (I-TEQ) have been revised and adapted for three of the 17 PCDD/Fs listed in the WID.

Table 85: Change of equivalence factors from the I-TEF concept by WHO in 1998 (changes marked in bold)

Dibenzo-p-dioxins	**I-TEF**	**WHO TEF 1998**	**Dibenzofurans**	**I-TEF**	**WHO TEF 1998**
2,3,7,8 Tetrachlorodibenzodioxin (TCDD)	1	1	2,3,7,8 Tetrachlorodibenzofuran (TCDF)	0.1	0.1
1,2,3,7,8 Pentachlorodibenzodioxin (PeCDD)	0.5	**1**	2,3,4,7,8 Pentachlorodibenzofu-ran (PeCDF)	0.5	0.5
1,2,3,4,7,8 Hexachlorodibenzodi-oxin (HxCDD)	0.1	0.1	1,2,3,7,8 Pentachlorodibenzofu-ran (PeCDF)	0.05	0.05
1,2,3,6,7,8 Hexachlorodibenzodi-oxin (HxCDD)	0.1	0.1	1,2,3,4,7,8 Hexachlorodibenzo-furan (HxCDF)	0.1	0.1
1,2,3,7,8,9 Hexachlorodibenzodi-oxin (HxCDD)	0.1	0.1	1,2,3,6,7,8 Hexachlorodibenzo-furan (HxCDF)	0.1	0.1
1,2,3,4,6,7,8 Heptachlorodibenzo-dioxin (HpCDD)	0.01	0.01	1,2,3,7,8,9 Hexachlorodibenzo-furan (HxCDF)	0.1	0.1
Octachlorodibenzodioxin (OCDD)	0.001	**0.0001**	2,3,4,6,7,8 Hexachlorodibenzo-furan (HxCDF)	0.1	0.1
			1,2,3,4,6,7,8 Heptachlorodiben-zofuran (HpCDF)	0.01	0.01
			1,2,3,4,7,8,9 Heptachlorodiben-zofuran (HpCDF)	0.01	0.01
			Octachlorodibenzofuran (OCDF)	0.001	**0.0001**

A new part of the TEQ (1998) system of WHO is the possibility to apply the concept not only to humans but also to mammals, birds and fishes.

In 2005, the WHO has discussed the toxic equivalence factors of 1998 and has again updated several figures [WHO 2005] due to new knowledge on toxicity. [Kalberlah et al. 2002]

The following table shows the WHO-TEQ of 2005 and in brackets the changes of the WHO-TEQ of 1998. WHO has announced to discuss and revise the TEQ factors all five years.

Table86: Toxic equivalence factors of PCDD/F and dioxin-like PCBs by WHO [2005], brackets: WHO [1998]

Substance	**human/mammals**	**birds**	**fishes**
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	1	1	1
1,2,3,4,7,8-HxCDD	0.1	0.05	0.5
1,2,3,6,7,8-HxCDD	0.1	0.01	0.01
1,2,3,7,8,9-HxCDD	0.1	0.1	0.01
1,2,3,4,6,7,8-HpCDD	0.01	< 0.001	0.001
OCDD	**0.000 3 (0.000 1)**	0.000 1	< 0.000 1
2,3,7,8-TCDF	0.1	1	0.05
1,2,3,7,8-PeCDF	**0.03 (0,05)**	0.1	0.05
2,3,4,7,8-PeCDF	**0.3 (0.5)**	1	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01	0.01
OCDF	**0.000 3 (0.000 1)**	0.000 1	< 0.000 1
3,4,4',5-TCB (81)	**0.000 3 (0.000 1)**	0.1	0.000 5
3,3',4,4'-TCB(77)	0.000 1	0.05	0.000 1
3,3',4,4',5-PeCB (126)	0.1	0.1	0.005
3,3',4,4',5,5'-HxCB (169)	**0.03 (0,01)**	0.001	0.000 05
2,3,3',4,4'-PeCB (105)	**0.00 3 (0.000 1)**	0.000 1	< 0.000 005
2,3,4,4',5-PeCB (114)	**0.00 3 (0.000 5)**	0.000 1	< 0.000 005
2,3',4,4',5-PeCB (118)	**0.00 3 (0.000 1)**	0.000 01	< 0.000 005
2',3,4,4',5-PeCB (123)	**0.00 3 (0.000 1)**	0.000 01	< 0.000 005
2,3,3',4,4',5-HxCB (156)	**0.00 3 (0.000 5)**	0.000 1	< 0.000 005
2,3,3',4,4',5'-HxCB (157)	**0.00 3 (0.000 5)**	0.000 1	< 0.000 005
2,3',4,4',5,5'-HxCB (167)	**0.00 3 (0.000 01)**	0.000 01	< 0.000 005
2,3,3',4,4',5,5'-HpCB (189)	**0.00 3 (0.000 1)**	0.000 01	< 0.000 005

4.4.1.3. BREF document on Waste Incineration

The Best Available Techniques Reference Document of Waste Incineration [BREF WI 2005] mentions in chapter 3 on air emissions that "PCB emissions are classified as potentially toxic by some international organisations (e.g. WHO). A toxicity potential (similar to that of dioxins and furans) is ascribed to some of the PCBs (coplanar PCBs)."

This is the only sentence in the BREF document stating that a toxic equivalence system may include dioxin-like PCB.

In general the BREF document uses "ng/Nm³ TEQ" or "ng/Nm³ I-TEQ" as units to indicate PCDD/F emissions. In the glossary, TEQ is defined as:
"Toxic Equivalents (used for expressing PCDD/F - refers to the same groupings and calculations detailed in EC Directive 2000/76 on the incineration of waste)".

4.4.1.4. Development of European Standard EN 1948

The European Standard EN 1948 (on stationary source emissions - determination of the mass concentration of PCDD/Fs) was first published in 1997.

EN 1948 is the reference standard for measurements of PCDD/Fs required by the Waste Incineration Directive.[125]

The Technical Committee 264 of the European Committee of Standardisation (CEN) was mandated by the European Commission to revise the European standard EN 1948-1997 developing an appropriate standard for the determination of the mass concentration of PCDD/Fs and dioxin-like PCBs. Until June 2006, the first three parts of the revised CEN Standard EN 1948 have been published; in October 2007 part 4 was released as Technical Specifications:

- Part 1: Sampling of PCDDs/PCDFs;
- Part 2: Extraction and clean-up of PCDDs/PCDFs;
- Part 3: Identification and quantification of PCDDs/PCDFs;
- Part 4: Sampling and analysis of dioxin-like PCBs.

The first three parts refer to the same toxic equivalent factors as used by the Waste Incineration Directive in Annex I ("I-TEQ").

The revised standard EN 1948-2006 defines dioxin-like PCBs as "each PCB which shows a similar toxicity as the 2,3,7,8-substituted PDCC/F according to the World Health Organisation (WHO)". It underlines in the scope of the standard that all provisions can also be applied for the determination of dioxin-like PCBs, although knowledge about specific boundary conditions of the method like confidence interval, detection limits etc are not yet availably as no validation had been undertaken so far.

Part 4 of the standard provides a list of toxicity equivalence factors including all three lists of toxic equivalence factors: I-TEQ, WHO-TEQ (1998) and WHO-TEQ (2005).

Part 4 has not the character of a European Standard (EN) but of "Technical Specifications" (Pre-Standard) because the methods have not been validated, yet. In 2007, a validation project has been carried out[126] to upgrade the Specifications to the level of a European Standard EN 1948-4 (results were not available yet). The upgrading of the Pre-Standard is scheduled to start in 2008 and likely be finished end of 2009 at earliest.

[125] "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." (WID, Annex III)
[126] the validation has be done at a dedicated waste incinerator in Vienna by three laboratories

Part 4 of the standard is optimized for a range of 0.01 ng WHO-TEQ PCB/m³. Additionally to the 12 PCBs listed by WHO with toxicity equivalence factors also six "indicator PCBs" (28, 52, 101, 138, 153, 180) can be measured with the specifications. The document provides procedures for quality control which have to be fulfilled by each method for sampling, extraction, cleaning, identification and quantification.

In November 2007, CEN Technical Committee 264 (Air Quality) has decided to aim at establishing a new work item in 2008 on the development of a standard specifically addressing automatic sampling systems for PCDD/F and PCB determination. [VDI 2007]

4.4.1.5. Assessment of the WHO-TEQ (1998) and WHO-TEQ (2005) regarding the emission limit value of the Waste Incineration Directive

A negligible relevance on emission values was evaluated, when using the three new settings (WHO TEQ 1998) in the current list of equivalent factors (I-TEQ). Therefore no need for an adaptation of the emission limit value for PCDD/Fs was concluded when using the new setting [Johnke et al. 2001].

The application of the WHO TEQ 2005 for PCDD/F would result in lower measurement results compared with I-TEQ application because the factors of two substances have been lowered significantly.

Regarding the extension of the TEQ list by dioxin-like PCBs, little analytical experience is available on the PCB emission levels of waste incineration and co-incineration plants. Most experience analysing dioxin-like PCBs has been gathered from the analysis of commercial PCB products and waste oil regarding a group of 6 PCBs ("Ballschmitter PCBs 28/52/101/138/153/180"), classified in draft standard 1948-2006-4 as indicator PCBs. This group has also been analysed in a few cases of PCB monitoring at waste incineration plants. The result shows a wide range of PCB concentrations of the different congeners from below the detection limit (2 ng/m³ for each parameter) up to values of 60 ng/m³. Likewise the sum of these 6 PCB congeners results in a wide range of values from 10 to 210 ng/m³ (all results below the detection limit set as 1 ng/m³). [Johnke et al. 2001] None of the 6 Ballschmitter-PCBs is listed in the WHO TEQ concept of 1998 and 2005.

Studies on open fire PCB analysis conclude that the amount of dioxin-like PCBs varies significantly. [BUWAL 2003] Measurements at two municipal waste incinerators, a sewage waste and a medical waste incinerator in UK, weighted with TEQ WHO (1998), show the following results:

Table 87: Measurements of dioxin-like PCBs at waste incinerators in UK [ng TEQ WHO (1998)/m³]

Municipal waste incinerator 1		Municipal waste incinerator 2				Sewage waste incinerator		Medical waste incinerator	
0.00004-0.012	0.0003-0.012	0.00005-0.015	0-0.015	0-0.014	0-0.016	0-0.012	0-0.012	0.00007-0.022	0.022-0.022

[Dyke 2002]

Other studies report contributions ranging from < 1 % to 20 % of total TEQ (WHO 1998), with an average of 2−4 % [Sinclair 2001].

For the small number of data, it is difficult at present to evaluate the effect of including dioxin-like PCB in the sum parameter of PCDD/Fs of the Waste Incineration Directive. Therefore it is not possible to assess, whether the present emission limit value of 0.1 ng/m^3 would need adaptation or not.

4.4.1.6. Origin and destruction of PCBs

In most European Member States the production of PCBs was stopped in the 70s and the use of PCBs in most products was banned in the 80s.

Nevertheless there is still a large number of PCB containing products in use, mainly cooling oils for transformers and capacitors (e.g. in motors of household equipment, in heat exchangers, and in starters of fluorescent tubes), hydraulic oil for mining equipment, elastic sealing and isolation material for buildings.

A separate collection of transformer cooling oil and electronic waste decreases PCB input in municipal waste incineration facilities and co-incineration plants, but this will not prevent regular PCB input of small amounts. Separate collection of PCB containing waste can be disposed or destroyed in specifically licensed plants.

According to the Stockholm POP declaration, the destruction of PCBs shall be done by using best available technology which means the application of techniques with efficiencies of about 100 %. Destruction of PCBs is possible with physical-chemical treatment or with high temperature incineration (> 1100°C) in licensed cement plants or licensed hazardous waste incinerators. (See inventory of world wide PCB destruction capacity [UNEP 1998]).

High destruction efficiency by incineration is only achieved, if the high temperature is achieved for a minimum of 2 seconds or residence time and with high oxygen excess of at least 6 %. If these conditions are not fulfilled, PCB may be converted into furans and also dioxins. [Vuceta et al. 1983] [Neidhard 1983] As the Waste Incineration Directive requires a minimum temperature of 850°C for at least 2 seconds, relevant PCDD/F formation from PCB input is not expected. No increased PCDD/F levels have been detected in well operated hazardous waste incinerators when incinerating high amounts of PCB [HIM 2007]

4.4.1.7. Summary and conclusions

The toxic equivalence factors of Annex 1, referring to 17 PCDD/Fs, can be expanded by toxic equivalence factors for dioxin-like PCBs. The latest update of TEQ has been done by WHO in 2005, comprising the 17 PCDD/Fs of the WID and 12 dioxin-like PCBs. Measurement of dioxin-like PCB is determined by a pre-standard 1948:2006-4 and will be upgraded to part 4 of EN standard 1948 in 2008/2009.

Although the standard EN 1948-2006 on determination of PCDDs/PCDFs in stationary source emissions mentions that there are still uncertainties regarding toxicity of PCDDs/PCDFs, it is underlined that the concept of toxic equivalence factors reflects all current knowledge about toxic effects of PCDDs/PCDFs and dioxin-like PCBs (limited to effects visible on the Ah receptor, not considering toxic effects of transport, intake and agglomeration of single congeners).

However, Technical Committee 264 of CEN resumes in EN 1948 that it seems rational to use the WHO-TEQ system in a sense of international harmonized risk assessment based on the state of the art of science.

As the WHO has realised amendments of the Toxic Equivalence Factors (and has announced to revise them all five years), it will be essential in the future to clearly indicate measurement results by specifying the TEQ concept used for the sum parameter. If a new TEQ concept is included in the WID, revision and adaptation of the TEQ concept should be foreseen when WID amendments are scheduled.

Up to now, the sum parameters may also vary depending on the way of including the single values of congeners that were measured below the detection limits.

Summarizing it has to be stressed in any future regulation that the sum parameter based on a TEQ system should indicate the following:

- Included substances (PCDDs/PCDFs or also dioxin-like PCBs),
- Applied toxic equivalence system (WHO-TEQ 2005 or I-TEQ etc.),
- Method used to include values below the detection limit: set as zero or included with the value of the detection limit[127].

If the limit value for the sum parameter would continue to be 0.1 ng TEQ/m^3, this obviously implies that the current limit value on dioxins and furans will become more stringent because additional PCB values will be added to the sum parameter. On the other hand, WHO-TEQ 2005 in comparison with the current I-TEQ includes two lower factors, one of them assigned to one of the most significant PCDD/Fs in emissions from waste incinerators.

It is not possible to predict the influence of an inclusion of dioxin-like PCBs and a change from the I-TEQ system to the WHO TEQ (2005). Studies show that the amount of dioxin-like PCBs in emissions of waste incineration varies significantly [BUWAL 2003], [Sinclair 2001].

[127] Not specified by the WID yet; different applications by laboratories in EU 27, resulting in different results for same measurements.

Higher PCB emissions can be expected from municipal waste incinerators where separate collection of electronic waste is not well established. If this precondition is given in combination with insufficient temperature control in municipal waste incinerators, temperatures near to the maximum PCDD/F formation by PCB (600-700°C) may occur which can cause also increased PCDD/F emission levels. No increased PCDD/F levels have been detected in well operated hazardous waste incinerators when incinerating high amounts of PCB [HIM 2007]

The CEN validation project on TS 1948-4 will not contribute data on the relation of dioxin-like PCBs and PCDD/Fs as the parallel determination of PCDD/F was excluded from the PCB measurement validation project.

Despite of these aspects it could be considered to require analysis of dioxin-like PCB and to extend the current list of PCDD/PCDF toxic equivalence factors by the group of dioxin-like PCB equivalence factors proposed by WHO in 2005. If clearly marked, this will contribute to achieving the aim of the Community Strategy on dioxins, furans and PCBs to assess the current state of the environment and the ecosystem, and to reduce human exposure and environmental effects from PCBs.

Alternatively to extending the current list of PCDD/PCDF toxic equivalence factors by the group of dioxin-like PCB equivalence factors of WHO (2005) an option could be to include a monitoring requirement for these substances without obligation to include the results in the sum parameter for PCDD/F when compliance with the emission limit value is monitored. This would lead to increased experience on the emission levels of dioxin-like PCBs and would ease the future determination of a combined limit value for the entire list of PCDD/Fs and dioxin-like PCBs. It was reported that additional dioxin-like PCB analysis will comprise additional laboratory costs of about 250 Euro per sample (this comprises about 50 % of PCDD/F analysis in most countries).

The economic burden of plant operators falling under the Waste Incineration Directive is rather limited for analysing the same amount of samples of dioxin-like PCB as for PCDD/F (twice a year with the possibility to apply for the exceptions of one measurement per year if PCDD/F values are below 50 % of the limit value), and has to be weighted against the value of achieving an increased knowledge about PCB emissions.

Economic burden is lower if the requirement of regular PCB monitoring is combined with the requirement for continuous PCDD/F monitoring by continuous sampling equipment as described in the following chapter (see also conclusion of the impact assessment on continuous PCDD/F monitoring).

4.4.2. Technical feasibility of continuous PCDD/F monitoring

4.4.2.1. Introduction

The following chapter analyses the technical feasibility of continuous monitoring of dioxins and furans. The subject is related to the provision of the Waste Incineration Directive, requiring the following action from the Commission:

"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." (Article 11 (13))

The Waste Incineration Directive currently requires from plant operators carrying out *"at least two measurements per year of dioxins and furans; one measurement at least every three months shall however be carried out for the first 12 months of operation."* (Article 10 (2) c)

A reduction of the frequency may be authorised from twice a year to once every year *"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."* (Article 10 (7))

The emission limit shall be regarded as complied with if "*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."* (Article 10 (10))

4.4.2.2. Continuous measurement of PCDD/F

No instruments for continuous measurement of PCDD/F are available so far. In recent years, the following systems for continuous measurement of PCDD/F have been developed in the USA [Coggiola et al. 2001]:

- SRI International Jet-REMPI (Resonance Enhanced Multi-photon Ionization)[128], a laser based system that produces ions which are typically detected using a time-of-flight mass spectrometer (TOFMS) based on the pulsed nature and well-defined temporal character of laser ionization,
- IDX Technologies, LTD. RIMMPA-TOFMS (Resonance Ionization with Multi-Mirror System Photon Accumulation Time-of- Flight Mass Spectrometer)[129], a laser-based mass spectrometry.

[128] see http://www.epa.gov/etv/pdfs/vrvs/600etv06049/600etv06049.pdf
[129] see http://www.epa.gov/etv/pdfs/vrvs/600etv06050/600etv06050.pdf

The systems are still in a testing phase and imply investment costs of about 500,000 EUR. Both techniques are not able to measure all 17 PCDD/F congeners directly.

If surrogates[130] are used for PCDD/Fs determination, variations in the ratio of PCDD/Fs have to be taken into account. Within the same incinerator, differences of about one order of magnitude between the ratios of PCDD/F congeners have been detected, explained by memory effects as well as by differences in their formation characteristics. When comparing different incinerators, differences in the ratio of PCDD/PCDF to surrogates of up to two orders of magnitude have been detected, explained with additional impact of altering ratios caused by different waste gas abatement techniques. [Weber 2005]

Memory effects, different formation characteristics and impacts of different waste gas abatement techniques on the ratio of PCDD/F congeners have to be more investigated and understood before surrogates can be used for a reliable indication of PCDD/F emission.

The relationship of surrogates and TEQ emission would have to be investigated for each incinerator to establish specific correlations. Due the complexity of the interrelationships, it will be difficult to verify these correlations if used for compliance checks. Continuous measurements of PCDD/F and surrogates may better be used to provide a more detailed understanding of an incinerator when considering and evaluating all effects. [Weber 2005]

Concluding it can be stated that considerable progress has been achieved with on-line measurement systems and some techniques are able to detect TEQ relevant higher chlorinated PCDD/PCDF. Nevertheless instruments for continuous measurement of all 17 PCDD/F congeners listed in Annex I of the Waste Incineration Directive are still under development and not market-ready, yet.

4.4.2.3. Continuous sampling of PCDD/F

Three techniques for continuous sampling of waste gas for subsequent measurement are available on the market, two of them since 1997, one since 2006:[131]

- DioxinMonitoringSystem® by Dioxin Monitoring GmbH, Austria, also distributed by Westech Instrument Services, UK,
- AMESA® by Environnement SA (former BM Becker Messtechnik), Germany,
- DECS – Dioxin Emission Continuous Sampling by TCR TECORA S.r.l., Italy.

130 For some correlation of the presence of PCBs and PCPs with PCDD/F formation, PCBs and PCPs have been examined as surrogates standing in as parameters to predict PCDD/F emissions.

131 see http://www.dioxinmonitoring.com, http://www.westechinstruments.com, http://www.environnement-sa.com, http://www.tecora.it

Most installations of the first two providers are applied for several years in a relevant number of installations for waste incineration and for waste co-incineration. Equipment of the third provider has been installed since 2006 in several installations for waste incineration and waste co-incineration.

The reference lists of the first two manufacturers in Annex 3 prove that the techniques are available and used on the market for many years.

The systems for continuous sampling are able to collect PCDD/Fs during a period which can be varied from some hours up to a maximum of 4 weeks. In most cases, sampling periods of 2 or 4 weeks are practised. After sampling, the sampling units (cartridges) are taken out of the system and are transferred in a transportation box together with the measurement protocol to a laboratory for analysis.

The three systems work according to each of the three analytical methods described in the European Standard EN 1948 2006 (Part 1) on "Stationary source emissions, determination of the mass concentration of PCDDs/PCDFs and dioxin-like PCBs" (see next chapter):

The DioxinMonitoringSystem® separates dioxins and furans from the gas phase and from the condensate in two steps: in the cooler and in the adsorbent. For dust collection, a plane filter is used. The cartridge containing the condensate, the dust filter and the adsorbent are sent to the laboratory for analysis.

The collected gas is transferred to a titanium mixing chamber where it is diluted with dried and cooled air. Thus, the sampled gas is cooled by keeping the dew point below the gas mixture temperature, which avoids condensation. The dry gas mixture then passes through a filter stack where the PCDD/Fs are collected. The filters are designed to collect the dust fraction and the gas fraction separately. (Compare EN-1948:2006-1 No. 5.1.3 dilution method)

The AMESA® system separates dioxins and furans from the gas phase and from the condensate in one adsorption step. For dust collection, quartz wool is used in the top of the XAD-II cartridge instead of a plane filter. Quartz wool and XAD-II cartridge are sent to the laboratory for analysis. Condensate does not need to be collected and analysed. (Compare EN-1948:2006-1 No. 5.1.4 cooled probe method)

The DECS system draws the sample by a heated probe and a thimble filter. The probe is first heated and then quickly cooled and filtered through an adsorbing cartridge, filled with XAD-II resin. (Compare EN-1948:2006-1 No. 5.1.2: filter/ condenser method)

All three systems imply investment costs of about 90-95,000 Euro. Additional costs for yearly maintenance, spares and calibration are about 3,000 to 6,000 Euros. All five years a standardised calibration implies costs of about 5,000 Euro. Costs for each PCDD/F analysis are around 500 Euro, varying from 400 Euro to 1,000 Euro.

Assuming a depreciation of 10 years and monthly analysis, yearly costs amount at about 26,000 Euro (in ten years: 2 standardised calibrations of 5,000 Euro each and 8 single calibrations of 3,000 Euro each; 1,000 Euro per year for maintenance and spares, 12,000 Euro for 12 analyses per year).

In comparison, current provisions of the Waste Incineration Directive generally require two measurements per year which implies costs of about 7,000 Euro.

4.4.2.4. Standardisation of PCDD/F monitoring

The European Standard EN 1948 on “Stationary source emissions, determination of the mass concentration of PCDDs/PCDFs and dioxin-like PCBs” from 1997 has been recently revised.

Three of four parts of the standard have been published in June 2006:

- Part 1: Sampling of PCDD/Fs;
- Part 2: Extraction and clean-up of PCDD/Fs
- Part 3: Identification and quantification of PCDD/Fs;

Part 1 of the standard on the sampling of PCDD/Fs does not describe special provisions for continuous sampling devices. Under the assumption that continuous sampling devices are used for compliance checking according to the EN Standard, all requirements also apply for continuous sampling devices.

The standard can be applied independently from the duration of the sampling period (several hours or several weeks), but the validation of the standard has been done for a sampling period of six hours. At present, the Waste Incineration Directive requires a sampling period for periodic PCDD/F measurements of minimum 6 hours and maximum 8 hours.

The results of all three continuous sampling systems, DioxinMonitoringSystem, AMESA and DECS, represent the average value of the waste gas concentration of the related measurement time, statistically weighed by the gas flow (isokinetic sampling), as required by the PCDD/F measurement standard EN 1948:2006-1 [EN 1948].

The AMESA® system is based on the cooled probe method described in EN-1948:2006-1 with the exceptions that the dust filter does not provide of the required retention efficiency[132] and the condensate flask is installed after the XAD-II cartridge[133]. Validation by an independent measurement institute (TÜV Rheinland, Germany) has confirmed that the losses of PCDD/F produced by the variation from EN 1948:2006-1 are neglect able.

The DioxinMonitoringSystem® system is based on the dilution method described in EN-1948:2006-1.

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[132] EN 1948-1:2006, No. 7.1: "99.5 % for a proof aerosol of 0.3 µm mean diameter or 99.9 % for an proof aerosol of 0.6 µm mean diameter, certified by the filter supplier [EN 13284-1:2001, 6.2.7]"

[133] This is in accordance with US EPA method 23A.

The DECS system is based on the filter/condenser method described in EN-1948:2006-1.

4.4.2.5. Acknowledgement by public authorities

The DioxinMonitoringSystem® system is used in installations of several countries, e.g. in Austria, France, Germany and Italy (see references in Annex 3). The system is proved by MCerts (Monitoring Certification Scheme of the National laboratory services of UK Environmental Agency[134]) and acknowledged by Austrian authorities fulfilling Austrian standards for continuous measurement instruments (ÖNORMs 9410, 9411, 9412 and 9414). It is also acknowledged by the US Environmental Technology Verification Program [EPA-1 2006].

The AMESA® system is alike used in several countries, e.g. in Belgium, France, Italy and Germany (see references in Annex 3). In 1997 it has successfully passed the pilot performance test of the Measuring Agency for Air Pollution of the Institute for Environmental Protection and Energy Technology [TÜV 1997], a performance test that is accepted by European authorities. The system is also acknowledged by MCerts (Monitoring Certification Scheme of National Laboratory Services of UK Environmental Agency) and the US Environmental Technology Verification Program [EPA-2 2006].

The DECS system is used in two countries, Italy and France. Since 2006, the system is proved by MCerts (Monitoring Certification Scheme of the National laboratory services of UK Environmental Agency[135])

In the Flemish region of Belgium, the application of the continuous sampling of PCDD/F taking 2-weeks-samples is obligatory for all incineration plants (with possible exemptions) since 2004. If the operator can prove evidence during one year that the emission values have permanently fallen short of the emission limit value, taking 4-week-samples may be authorised [Umans 2007] Continuous dioxin measurement results are applied to compare emissions in an indicative way against the emission limit value (which is then called "threshold value"). For the real compliance check with the emission limit value, the periodic measurements according to EN 1948 are still required.[136] Requirements to have such measurements have been included in individual permits since 1998. A guide on good practice concluded in 2002: “By practical experience on several installations in Flanders it has been shown that 2-weeks-samples are sufficiently functional to detect substantial deviations in the dioxin emissions within the acceptable measurement uncertainty.” [De Fré et al. 2002]

In Walloon region of Belgium a system of continuous sampling has been financed and installed by public authorities for the monitoring of PCDD/F emissions at all municipal waste incineration plants. Results of the measurements (2-weeks-samples) are available on the internet.[137]

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134 http://www.wrcapproved.com/asp/mcerts.asp

135 http://www.wrcapproved.com/asp/mcerts.asp

136 see legislation: http://www.emis.vito.be/wet_ENG_navigator/vlarem2-part5-chapter2.htm

137 Direction générale des ressources naturelles et de l'environnement : http://environnement.wallonie.be/data/air/dioxines/

At least one permit in Germany of a chipboard waste incineration plant provides the possibility for the competent authority to cut out periodic measurement requirements relying only on continuous sampling results. However, this possibility was not used. In Germany no case is known where periodic measurement is cut out in favour of a continuous sampling system.

In Austria, one permit of a municipal waste incinerator includes the provision to measure PCDD/F not only periodically according to WID provisions but also to store automatically taken PCDD/F samples each 4 weeks. [Arnoldstein 2002]

US EPA has allowed the use of automatic sampling methods instead of periodic sampling requiring or a final performance specification from monitors or an approval of a site-specific monitoring plan:

"In place of dioxin/furan sampling and testing with EPA Reference Method 23, an owner or operator may elect to sample dioxin/furan by installing, calibrating, maintaining, and operating a continuous automated sampling system for monitoring dioxin/furan emissions discharged to the atmosphere, recording the output of the system, and analyzing the sample using EPA Method 23. This option to use a continuous automated sampling system takes effect on the date a final performance specification applicable to dioxin/furan from monitors is published in the Federal Register or the date of approval of a site-specific monitoring plan. The owner or operator of an affected facility who elects to continuously sample dioxin/furan emissions instead of sampling and testing using EPA Method 23 shall install, calibrate, maintain, and operate a continuous automated sampling system and shall comply with the requirements specified in paragraphs (p) and (q) of this section." [EPA-3 2006]

The US Environmental Technology Verification Program has tested the performance of two dioxin monitoring systems. The results have been evaluated in terms of relative accuracy (RA), range, data completeness and operational factors (ease of use, maintenance, and consumables/waste generated). RA and range were determined by comparing the results of the systems to those from US Method 23 reference samples collected simultaneously.

The DioxinMonitoringSystem was evaluated with a relative accuracy of 22.6 % (reference samples: N/A) and a range of 9.7 % (reference samples: 8.4 %) [DioxinMonitoring 2006]. The AMESA system was evaluated with a relative accuracy of 48.2% and a relative standard deviation of 21.9 % [AMESA 2007].[138].

Whereas periodic measurement is normally executed by independent measurement institutes, automatic sampling systems can be operated by plant staff also, meaning that cartridges are taken out of the system and sent to the laboratory. Whereas some public authorities allow plant operators to change cartridges and organise transport to laboratories, other public authorities have taken measures to ensure that manipulation is minimized:

[138] The US ETV report notes: "Because of the non-standard installation, it is possible that leaks occurred in the sampling train, which can result in a negative bias in analytic concentration."

- in general, electronic systems registering the sampling period can not be manipulated
- in Belgium, sampling boxes have to be locked and cartridge change may only be executed by public authorities or acknowledged institutes
- in Flanders/Belgium, the code of good practise has to be applied for automatic PCDD/F sampling systems [De Fré et al. 2002]

In contrast with these acknowledgments, a study of the Environmental Agency [2006] in UK has detected differences between periodic PCDD/F measurement compared with the continuous sampling systems AMESA and DioxinMonitoringSystem as well as differences between these systems.

However, it is resumed that both continuous measurement systems have shown ability to track the trends in dioxin concentrations. The authors have the readers consider that extremely low levels of PCDD/F were found meaning that the study was working at the limit of what it is possible to measure with any certainty. Providers of the investigated systems have commented critics on the study assuming that periodic samples have not been analysed after optimum storage conditions.

The UK study also mentions that the measurement systems are designed to operation at a fixed sampling point (DioxinMonitoringSystem at two sampling points) and therefore would not comply with EN 13284-1:2002 to ensure that a representative dust (and hence dioxin) sample is collected. [139] The criticism was based on the former version of EN 1948:1996. The revised version of EN 1948:2006 requires reporting the deviation from EN 13284-1, if no multipoint sampling has been realised.[140]

In November 2007, CEN Technical Committee 264 (Air Quality) has decided to aim at establishing a new work item in 2008 on the development of a standard specifically addressing automatic sampling systems for PCDD/F and PCB determination. [VDI 2007] This means that a Technical Specification may be published in 2010 and a validated EN Standard earliest in 2011.

4.4.2.6. Summary and Conclusions

Systems for on-site analysis of all 17 PCDD/F congeners by continuous measurement systems are still under development. Existing techniques are able to measure a limited number of PCDD/F congeners. The systems imply high investment costs and extensive training as well as experience for operating the systems.

[139] EN 13284: Stationary Source Emissions – Determination of Low Range Mass Concentration of Dust Part 1 - Manual Gravimetric Method

[140] EN1948:2006, No. 9.3.2.4: Sampling shall be carried out according to EN 13284-1:2001, on at least two sampling lines. If this is not possible for some existing installations, sampling shall be undertaken at multi points along a single sample line, but this may not be to the stated precision. Such deviations from the Standard shall be fully reported.

At least three automatic continuous sampling systems for PCDD/F monitoring are available on the market. Two of them have proved its reliability in a relevant number of incineration plants for about 10 years; one system is applied since 2006. The systems are certified by certification systems that are acknowledged by public authorities. Two systems correspond to the procedures of the standard EN 1948, another system is acknowledged to give corresponding results.

It is intended by CEN to start working on a standard specifically addressing automatic sampling systems for PCDD/F and PCB determination in summer 2008, which means that a Technical Specification may be published in 2010 and a validated EN Standard earliest in 2011.

No procedures regarding the change of cartridges and transport to laboratory are described in standards or established European wide. A change and collection by certified laboratories is recommended.

It can be concluded that a reliable determination of the total mass of PCDD/Fs in waste gas is possible by continuous monitoring systems. Measurement periods have to be fixed by public authorities, e.g. for 2 or 4 weeks, implying different measurement costs.

Whereas 4-week-sampling periods imply annual total costs of about 26,000 Euro, 2-week-sampling periods imply annual costs of about 38,000 Euro (assuming 10 years depreciation of investment).

If only acknowledged persons are allowed to change and transport samples, total costs will increase by about 500 Euro per sampling (varying according to day rates and distances to laboratories). This means that annual costs will amount to about 32,000 Euro for a 4-week-sampling period and to about 50,000 Euro for a 2-weeks-sampling period.

These costs are reduced by current measurement costs for PCDD/F monitoring. Current measurement costs depend on the location of the plant (some national transpositions of the Waste Incineration Directive require more than two measurements per year). Regular costs of about 3,500 Euro per measurement will also decrease if journey and installation of equipment has to be realised only once because competent authorities accept measurements at subsequent days.

4.5. Analysis of impacts of continuous PCDD/F monitoring

4.5.1. Problem definition

For incineration and co-incineration plants, the Waste Incineration Directive does not require continuous measurement of PCDD/F. It requires from plant operators carrying out *"at least two measurements per year of dioxins and furans; one measurement at least every three months shall however be carried out for the first 12 months of operation."* (Article 10 (2) c)

A reduction of the frequency may be authorised from twice a year to once every year *"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."* (Article 10 (7))

The emission limit shall be regarded as complied with if "*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."* (Article 10 (10))

The emission limit value is defined as 0.1 ng/m^3 for all installations covered by the Directive (Annex II 1.1, Annex II 2.2, Annex 3.1, Annex V), calculated using the concept of toxic equivalence factors according to Annex I (I-TEQ concept based on NATO-CCMS).

The feasibility study on continuous PCDD/F monitoring has shown that techniques for continuous (on line) measurement (not sampling) of PCDD/F have made some progress, but instruments measuring all relevant PCDD/F congeners are not available, yet. Studies on PCDD/F correlation with surrogates like PCBs and PCPs have not come to satisfying results neither, especially not for the purpose of compliance checking.

However, at least three measurement instruments for continuous monitoring of PCDD/Fs are available, sampling continuously and analysing the samples after periods of up to four weeks. At present, most samples are analysed after two weeks or after four weeks. Three instruments are acknowledged by independent test organisations (TÜV, MCerts) of giving analytical results according to the CEN measurement standard on dioxins and furans.

Instruments for continuous monitoring are applied and experienced for about 10 years in waste incineration plants, cement plants, fossil and biomass power stations, smelter furnaces and sulphuric acid plants.

4.5.2. Objective of the proposal

The object of the proposal is to assess the effects of implementing continuous monitoring of PCDD/F according to the action required from the Commission by Article 11 (13) of the Waste Incineration Directive, to implement continuous monitoring of PCDD/F as soon as appropriate measurement techniques are available.

The proposal aims at continuous monitoring of PCDD/F emissions from waste incineration and co-incineration plants, achieving enhanced process and emission control.

This objective also supports

- the aim of the Waste Incineration Directive (Article 1) to prevent or limit emissions into air, as far as practicable,
- the aims of the 6th Environmental Action Programme and the Commission's strategy on PCDD/F and PCBs (COM 2000/593),
- the objectives of international conventions like the OSPAR convention for marine environment protection of the north-east Atlantic (1998), and the convention for marine environment protection of the Baltic See,
- the aims of the UNECE POP protocol on long range transport of persistent organic pollutants (1998) and the international Stockholm POP convention (2001).
- the aims of the World Health Organisation to gradually eliminate the exceedances of critical loads, respecting daily intake levels for health protection.

4.5.3. Procedural aspects

As agreed with the Commission Services, the following assessment covers the options "Business as usual" and "Amendment of the Waste Incineration Directive: Inclusion of the requirement of continuous sampling of PCDD/F".

Data has been used from the feasibility study on continuous PCDD/F monitoring (see chapter 4.4.2), as well as from literature study, from consultation of instrument suppliers, public authorities, industry associations and individual plant operators.

4.5.4. Policy options

The following options are assessed:

1) Business as usual: No amendment of the Waste Incineration Directive. In this scenario, continuous sampling of PCDD/F may be applied to incineration and co-incineration plants if continuous PCDD/F monitoring is re-

quired by individual Member State regulations or through individual (IPPC or WID) permits.

2) Amendment of the Waste Incineration Directive: Inclusion of the requirement of continuous sampling of PCDD/F by Amendment of Article 11. Measurements shall be carried out by instruments acknowledged to fulfil the CEN standards for PCDD/F sampling. Sample cartridges shall be collected by acknowledged laboratory staff. Measurement instruments shall be calibrated with parallel periodic measurements according to CEN standards for calibration of continuous monitoring devices.
Sub-option 2 a) foresees an implementation in all plants without exemptions, requiring analysis of samples after two weeks.
Sub-option 2 b) (based on practice in BE-Flanders) foresees that exemptions can be granted as following: If after a period of one year of analysing all 2 weeks (26 analyses) none of the values has exceeded the emission limit value of 0.1 ng TEQ/m^3, a four week sampling period may be allowed. This exemption shall no longer be valid if a value of a subsequent four week sampling period has exceeded the emission limit value of 0.1 ng TEQ/m^3. It is assumed that 50 % of the affected installations will be able to be subject of the exemption.

4.5.5. Priority impact categories

Priority impact categories of these options are:

1) Economic impacts: Most relevant impact categories are competitiveness, competition in the internal market, trade and investment flows, operating costs, administrative costs. Little relevance is expected for the categories specific regions, consumers and households, innovation and research, public authorities. No relevance of the categories conduct of business, property rights, third countries, international relations and macroeconomic environment.

2) Environmental impacts: Most relevant impact categories are air and water quality, environmental risks, soil quality, animal health, food and feed safety, biodiversity, flora and fauna. No relevance of the categories climate, use of energy, renewable or non-renewable resources, landscapes, land use, waste production, waste recovery and mobility (transport modes).

3) Social impacts: Most relevant impact categories are public health and safety, workers' health, good administration, public confidence in incineration and co-incineration of waste, employment and labour markets. Categories with no priority are standards and rights related to job quality, social inclusion and protection of particular groups, equality of treatment and opportunities, non-discrimination, private and family life, personal data, governance, participation, access to justice, media and ethics, crime, terrorism and security, access to and effects on social protection, educational systems.

4.5.6. Affected stakeholder groups

4.5.6.1. Waste incineration and co-incineration industry

At present, no Member State has implemented requirements on continuous sampling of PCDD/F but the Belgium regions Flanders and Wallonia, comprising at least 17 dedicated waste incinerators and 3 cement plants, require continuous PCDD/F monitoring in waste incineration and co-incineration plants.

According to the data that became available during data collection 1400 incineration and co-incineration plants were identified in total. The largest group are dedicated waste incinerators (40%) followed by combustion plants (15%) and cement plants (9%).

Taking into account that some stakeholders did not deliver information and concluding from expert interviews and literature research it is estimated that a total of 1800 plants incinerate or co-incinerate waste in Europe[141].

- Most plants are not yet subject of continuous sampling of PCDD/F. They would be affected by option 2 and eventually by option 1, depending in the latter case from Member State regulations and permits.
- Nor option 1 nor option 2 will affect plants in Flanders and Wallonia regions of Belgium as a general requirement on continuous PCDD/F sampling is in force (at least 17 waste incinerators and 3 cement plants).
- Measurement instrument suppliers have reported references on about 100 permanent applications of PCDD/F sampling systems in several sectors in Europe (about half of them being subject to the Waste Incineration Directive) as well as further periodical applications.
- It is assumed that about 70 plants being subject to the Waste Incineration Directive have installed continuous PCDD/F sampling systems. This is equivalent to be about 4 % out of a total of 1800 installations.
- If 40 % of a total of 1730 plants operating under the Waste Incineration Directive without PCDD/F sampling are dedicated waste incinerators, this results in 692 such plants possibly being subject of option 2 (Amendment of the Waste Incineration Directive including a general requirement of continuous PCDD/F monitoring).

[141] It has to be taken into consideration that some data uncertainty exists.

◦

◦ If 60 % of a total of 1730 plants operating under the Waste Incineration Directive without PCDD/F sampling are waste co-incinerating industries, this amounts up in 1038 such plants possibly being subject of option 2 (Amendment of the Waste Incineration Directive including a general requirement of continuous PCDD/F monitoring).

4.5.6.2. Suppliers of PCDD/F instruments and laboratories

◦ Additionally to waste incinerating or co-incinerating industries, suppliers and maintainers of PCDD/F sampling instruments are affected.

◦ Furthermore, laboratories for PCDD/F analysis are affected.

4.5.6.3. Consumers and households

⇨ Consumers and households would only be affected if waste disposal prices or cement prices would rise.

4.5.6.4. Public authorities

◦ Public authorities are concerned as far as they are involved in monitoring (evaluation of reports).

4.5.6.5. Environment

⇨ Air, water, soil and wildlife is mainly concerned.

4.5.6.6. Social aspects

⇨ Health aspects and public confidence are of main relevance.

4.5.7. Analysis of impacts – Option 1: Business as usual

4.5.7.1. Possible development in the context of implementing option 1

In this option, implementation of continuous monitoring of PCDD/F emissions depends on national regulations and on permit decisions. At present, PCDD/F monitoring is not explicitly listed as BAT in any of the relevant BREF documents. [BREF WI 2005] [BREF C+L 2000] [BREF LCP 2003]

Therefore, no definitive time line of implementing continuous PCDD/F monitoring in a relevant number of plants is related with option 1 (business as usual).

4.5.7.2. Economic effect of option 1

The implementation of option 1 (business as usual) has negative effect for industry as there will be no level playing field regarding the need for investment in continuous PCDD/F monitoring systems in EU 27 due to different Member States regulations and permitting practices.

It is assumed that national or regional requirements for continuous PCDD/F monitoring will be implemented in few Member States (10-20 % of the installations). Hence, investment costs of about 95,000 Euros per instrument are not implied at all installations at the same time, which has a negative effect on internal competition, although considered as relatively small due to the relatively small investment sum compared with regular turn-over of several million Euros.

The implementation of option 1 is considered to have small influence on investment cycles and on cross-boarder investment due to the relative small investment amount. Same is valid for effects on trade and on macroeconomics. No effect on European trade policy is expected.

No relevant effect on public authorities is expected as evaluation of monitoring results is similar to the effort of periodic measurements.

4.5.7.3. Environmental effects of option 1

Non-detected, non-reduced PCDD/F emissions have a negative effect on ecosystems and wildlife (which can not be quantified due to lack of data on currently occurring non-detected peak emissions).

Option 1 will not lead to EU 27 wide implementation of continuous PCDD/F sampling. Single implementation of continuous monitoring requirements in some Member States (about 10-20 % of the installations) will not decrease significantly the risk to exceed emission limit values of PCDD/F.

About 80 – 90 % of the installations in Europe will continue to have a casual monitoring of performance which is highly influenced by the elected moment of measurement. Measurement can be organised at best performing periods of the waste gas abatement and with highest attention on process-control.

Assuming 8000 hours of operation, PCDD/F monitoring during 12 hours covers only 0.15 % of the operation time. No information about the remaining time is available about a group of substance that is considered as very toxic.

Assuming 8000 hours of operation, PCDD/F monitoring during 12 hours covers only 0.15 % of the operation time. No information about emissions at the remaining time is available about a group of substances that is considered as very toxic. The amount of such undetected PCDD/F emissions can not be quantified nor estimated because these emissions occur on varying levels and as short term or as long term peaks.

4.5.7.4. Social effects of option 1

Peak or increased levels of PCDD/F emissions of the respective plants can not be detected efficiently as long as only periodic measurement of PCDD/F is executed. Continuous sampling does not lead to an immediate detection of peaks but to the detection of highly exceeded emissions during two or four week sampling periods.

Non-detected, non-reduced PCDD/F emissions have negative effects on human health (can not be quantified due to lack of quantifiable data on long-term or short-term peak emissions). No relevant contribution to public confidence in waste incineration is given by option 1 because the lack of monitoring of PCDD/F means a high level of uncertainty regarding negative health impacts.

4.5.8. Analysis of impacts – Option 2: requiring continuous PCDD/F sampling, analysing all two weeks with the possibility to change to a four week sampling and analysing period

4.5.8.1. Description of the actions to be taken under option 2 - implementing continuous PCDD/F sampling requirements

At present, PCDD/F levels are only monitored continuously in Flanders and Wallonia as well as in some other plants. In case of low performance of waste gas abatement, PCDD/F peak emissions can occur without detection. Periodic measurements are casual impressions of the performance of the waste gas abatement system.

At present, incomplete combustion may only be detected if TOC and CO levels increase. Only in this case plant operators will be able to decide on measures to improve the performance of the waste gas abatement system.

PCDD/F emissions are subject to memory effects and therefore do not necessarily occur in parallel with increased CO emissions.

By implementing option 2, peak emissions can be detected after two or four week sampling, thus results will be available after four to six weeks. If high PCDD/F values are determined, plant operators can take adequate measures. Continuous sampling will lead to regular measurement results which can increase operators' awareness on keeping or improving the performance of the waste gas abatement system.

Option 2 requires the installation of continuous PCDD/F sampling equipment and a sample collection as well as analysis by an acknowledged laboratory after two weeks. Option 2a) does not foresee exemptions, option 2 b) foresees an exemption: If evidence can be given that no exceedances of the emission limit value has occurred during one year of monitoring, a change to a four week sampling and analysing period may be granted by the competent authority.

An additional effect of implementing option 2 is that PCDD/F peak emissions during start-up and shut down periods can be detected with little cost implications by making additional analysis of these periods. Separate measurement during start up and shut down could be required, if long-term measurements show increase of 2- or 4-week sampling results.

4.5.8.2. Economic impact of option 2

Investment costs for the measurement equipment are about 90-95,000 € [AMESA 2007], [DioxinMonitoring 2007], [Tecora 2007]. Yearly costs for maintenance and spars are about 3,000 Euros, for operation about 250 Euros. [AMESA 2007]

It is assumed, that PCDD/F sampling equipment is currently installed in Belgium at all municipal waste incinerators of Flanders and Wallonia region (17 plants). The total number of installed equipment is estimated with 70 in EU 27.[142]

Based on 1800 installations falling under the WID in EU 27, about 1730 installations have to invest in at least one unit of PCDD/F sampling.[143]

The current requirement to perform two measurements of PCDD/Fs per year implies total annual costs of about 7,000 Euros.

Due to national requirements, about 10 % of installations are currently obliged to carry out more than two measurements of PCDD/F per year: e.g. in Germany three measurements (comprising total costs between 5,000-9,000 Euros), and in Austria twice three independent measurements (comprising total costs of between 10,000 and 18,000 Euros).144

According to EN 14181 on quality assurance of automated measuring systems, all five years a calibration with at least 15 periodic measurements is needed (each taken over a period of at least 6 hours). Every calibration will imply costs for personal (on 7 days) of about 5,000 Euros and additional analytical cost of about 7,500 Euros, summing up with 12,500 Euros per calibration, equivalent to 2,500 Euro per year.

Assuming depreciation for the measurement instrument of 10 years, capital costs of 10 %, calibrations all 5 years, costs for sample analysis of 500 Euro, sample preparation and extraction about 150 Euro, the following annual costs are implied or with a 2-week sampling period or with a 4-week sampling period.

[142] see reference list of providers in Annex

[143] The total number of stacks to be measured is not known. Some installations have several lines and one stack, some have more than one stack.

[144] In most cases it is allowed to carry out measurements at consecutive days, thus sum of costs is lower than for three single measurements at independent days.

Table 88: Costs estimation of continuous PCDD/F monitoring with 2- or 4-weeks sampling periods

	Costs per unit [€]	4-weeks sampling		2-weeks sampling	
		Quantity	Costs [€]	Quantity	Costs [€]
Depreciation (10 y)	9,250	1	9;250	1	9,250
Capital cost (10 %)	4,950	1	4,950	1	4,950
Operation	250	1	250	1	250
Maintenance/spares	3,000	1	3,000	1	3,000
Yearly calibration	2,500	1	2,500	1	2,500
Sample preparation	100	13	1.300	26	2,600
Sample extraction	50	13	650	26	1,300
Sample analysis	500	13	6,500	26	13,000
Total annual costs			**28,400**		**36,850**

The following table shows additional costs for continuous measurement, depending on the sampling period and on the current requirements for monitoring.

Table 89: Additional costs for PCDD/F monitoring with 2- or 4-weeks sampling periods

	4-weeks sampling Costs [€]			2-weeks sampling Costs [€]		
# periodic meas.	2	3	6	2	3	6
Continuous meas.	28,400	28,400	28,400	36,850	36,850	36,850
Current costs for periodic meas.	7,000	5,000 * - 9,000	10,000- 14,000	7,000	5,000 * - 9,000	10,000- 14,000
Additional costs	20,900	18,400- 23,400 *	14,400- 18,400	29,350	31,850- 27,850 *	26,850- 22,850
* if measurements are allowed on consecutive days						

The table shows that about 90 % of the installations will have additional costs of 20,000 Euro for a 4-week sampling and 30,000 Euros for a 2-week sampling period. The remaining installations will have additional costs between 14,000-23,000 Euros respectively 23,000-32,000 Euros. Plants having installed continuous sampling (mainly in Wallonia and Flanders) have no additional costs.

Assuming a gate fee of 100-160 Euros per ton at dedicated waste incinerators, an implementation of option 2 with a 2-week-sampling period will account for about 0.1-0.2 % of the turn over of average plant size of 150,000 tonnes of waste input capacity per year, about 0.1 % of a large plant (300,000 tonnes capacity) and about 0.3-0.6 % of a small plant (50,000 tonnes capacity).

Based on these figures it is estimated, that by implementing continuous PCDD/F monitoring, treatment costs per tonne of waste increase between 0.42-0.59 € per tonne in small plants, 0.14-0.2 € per tonne in medium size plants and 0.07-0.1 in large plants for a 2-week sampling period (equivalent to 0.1-0.9 %).

For a 4-week sampling period, treatment costs increase between 0.67-0.97 € per tonne in small plants and 0.11-0.16 € per tonne in large plants (equivalent to 0.07-0.1%).

For co-incinerating industries the gate fees are about half the price of dedicated waste incinerators, therefore negative investment and operating effects are lower. In a cement plant co-incinerating an amount of 100,000 tonnes of waste per year with a gate fee of 40 Euros per ton, additional measurement costs of about 38,000 Euros for a 2-week-sampling period sum up with 1 % of the gate fee, thus 0.40 Euro per tonne of waste.

Assuming cement prices of 60 Euro and a clinker rate of 85 %, in a plant producing 1500 tonnes per day on 320 days the additional monitoring costs of 38,000 Euros for a 2-week-sampling period amount with 0.08 Euro per tonne of clinker respectively 0.1 % of the cement price.

The figures show that the economic impact on affected industries is relatively small, thus effects on international markets are not seen as relevant.

Total costs of implementing option 2 a) (2-week-sampling obligatory):
Assuming the need for installing PCDD/F monitoring in about 1730 installations, [145]total investment costs (92,500 € per instrument) are about 160 m Euro.

Total annual costs (assuming annual additional costs of 60,000 Euro) sum up with 104 m Euro for implementing option 2 a) (additional to present analytical costs).

Total costs of implementing option 2 b) (2-week-sampling and possibility to grant exemptions with 4-week-sampling-periods in about 50 % of installations): Total investment costs are the same as by option 2 a) (about 160 m Euro). For the calculation of total costs (annual capital costs and operating costs), annual costs of 60,000 Euro for 2-weeks-sampling and 40,000 Euro for 4-week-sampling are assumed. Under these assumptions, total annual costs are 87 m Euro for option 2 b) (additional to present analytical costs).

These figures on total costs do not take into account that some plants have more than one line and thus in some cases more than one stack to be monitored.

Effects on internal markets are not seen as relevant because the requirement is the same for all installations under the Waste Incineration Directive.

A significant effect is expected for small installations (e.g. waste incinerators, small lime plants) as investment of 95,000 Euros comprises a relative high burden compared with medium and big installations. No data is available on the number of small installations.

Little effect on consumers and households is expected because annual costs of a two week sampling period of PCDD/F amount with 38,000 Euros; this is equivalent to about 0.25 Euro per tonne of waste (for a plant capacity of 150,000 tonnes) or about 1.5 % of a consumers' disposal price for waste collection and incineration of about 160 Euros per ton.

[145] Not taking into account that some installations have more than one stack and therefore need more than one equipment.

Besides the described effects on waste incineration and co-incineration industry, implementing option 2 will have a direct positive economic effect on measurement instrument suppliers as more instruments are brought on the market and more research and development will be possible.

Implementing the option will also have a direct positive economic effect on laboratories, as these will profit from performing the measurements.

Little economic impact on public authorities is expected as monitoring efforts are similar to present efforts. It is expected that during the first two years more exceedances of emission limit values are detected and efforts of public authorities for implementing appropriate correction measures will imply additional time of competent staff.

4.5.8.3. Environmental effects of option 2

Non-detected, non-reduced PCDD/F emissions have a negative effect on ecosystems and wildlife (can not be quantified due to lack of data on peak emissions). The amount of such undetected PCDD/F emissions can not be quantified nor estimated because these emissions occur on varying levels and as short term or as long term peaks.

Implementing continuous PCDD/F sampling can lead to reduced risk of exceeding emission limit values and has a potential for reducing emissions resulting from peaks that are otherwise not detected. The implementation will lead to awareness rising of plant operators and improved attention to achieve optimum burn out conditions.

This effect is limited because no reaction in short time is possible due to the sampling periods of minimum 2 or 4 weeks.

No effect is expected in Belgium, as option 2 is already implemented in Flanders and in Wallonia regions.

Cross-media effects are not expected by implementing option 2.

4.5.8.4. Social effects of option 2

Implementing option 2, health risks from peak or increased emissions are reduced simultaneously in all installations under the Waste Incineration Directive (see environmental effects).

The benefit on human health can not be quantified due to the lack of data on long-term and short-term peak emissions. Hints on the existence of such peak emissions during start-up and during regular operation are reported by a study of the UK Environmental Agency [2006].

Implementation of option 2 contributes to public confidence in waste incineration because monitoring of PCDD/F means a reduced level of uncertainty regarding negative health impacts.

4.5.9. Comparison of options

Implementing option 1 will not lead to significant reduction of risks on environmental and health. It is assumed that "business as usual" will lead to installation of continuous monitoring of PCDD/F in about 10-20 % of installations. All other installations will continue to realise periodic measurements that can give casual impressions of the performance of the abatement systems about 0.15 % of operating time.

Option 1 is related with a high uncertainty concerning increased monitoring of PCDD/F because the implementation is dependent from national Member State policy, and from permit decisions at individual plants. No level playing field is achieved.

Option 2 harmonises the implementation across Europe in a better way than option 1 (business as usual) by implementing a new requirement at the same time for all installations

Economic impacts on affected industries are seen as rather limited but will have significant effect for small plants, such as small waste incinerators and small lime plants. As no data on the number of small plants is available, the effect can not be quantified.

Option 2 provides information about average emission levels and about total amounts of emissions. This is in line with the Community Strategy on PCDD/F.

By implementing option 2, the environmental and health risks related with PCDD/F emissions are significantly reduced and the awareness of operators is increased by permanent improved performance control of the waste gas abatement system.

As PCDD/F is seen as the most critical parameter for public acceptance of waste incineration, continuous monitoring can increase acceptance and support strategies to minimise disposal.

Relevant cross-media effects are not expected for any of the two options.

4.5.10. Combination of PCDD/F monitoring and PCB monitoring

Assessing the feasibility of PCB monitoring (see chapter 4.4) it was recommended to start monitoring PCB emissions without setting a limit value based on latest WHO toxic equivalent factors for PCDD/F and dioxin-like PCB.

The establishment of option 2 regarding PCDD/F monitoring by continuous sampling systems offers the possibility to analyse PCB using the same samples. Additional costs depend on the requested number of PCB analyses.

If option 2 b) is implemented (2-week-sampling periods with the possibility to grant exemptions with 4-week-sampling periods), it is recommended to generally request PCB analysis all 4 weeks (12 measurements per year).

Assuming additional analytical costs of 250 Euro per analysis, additional costs per plant sum up with 3,000 Euro per year. Implementation in about 1800 installations would mean additional monitoring costs for PCB of 5.4 m Euro (not taking into account eventual need for monitoring at different stacks).

4.6. Technical feasibility of continuous heavy metal monitoring

4.6.1. Introduction

The following chapter assesses the feasibility of implementing continuous monitoring systems for heavy metals in waste gases.

The subject is related to the provision of the Waste Incineration Directive, requiring the following action from the Commission:

"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." (Article 11 (13))

The Waste Incineration Directive currently requires carrying out *"at least two measurements per year of heavy metals; one measurement at least every three months shall however be carried out for the first 12 months of operation."* (Article 10 (2) c)

A reduction of the frequency may be authorised from twice a year to once every two years *"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."* (Article 10 (7))

The emission limit shall be regarded as complied with if "*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."* (Article 10 (10))

4.6.2. Development of continuous measurement for metals other than mercury

For continuous metal monitoring other than mercury, no European Standard has been developed.

Several test applications have been conducted with measurement instruments. A summary of the status of continuous measurement instruments for heavy metals was published in 2002. [Monkhouse 2002]

Tampere University in Finland has developed a pilot measurement instrument employing direct current (dc) plasma excited atomic absorption spectroscopy.

This technique has been demonstrated for continuous measurement of heavy metals in process gases. Process gas is continuously sampled along a heated sample line. Metal compounds contained in the gas are thermally decomposed by mixing the gas with a plasma jet produced with a dc nitrogen plasma torch. Transmission of monochromatic light is measured through the gas jet, and absorbance caused by metal atoms is distinguished from the background.

The detection limits of the current prototype are 0.04 mg/m^3 for cadmium and 0.4 mg/m^3 for lead. The measurement accuracy is better than 20 %, and the maximum measurement rate is about 100 values per minute. The instrument was designed to withstand wet, corrosive, and particulate-laden flue gases at temperatures up to 1100 °C. The instrument can also be used, after minor modification, for measurements at pressurized conditions. The performance of the instrument was demonstrated in connection with a fluidized bed incinerator. [Oikari et al. 2001] The detection limits of the instrument was not satisfying and improvement of the instrument were expected too be too cost intensive for offering a marked-ready product to possible applicants. [Hernberg 2007]

Sheffield University in UK has developed a pilot instrument for continuous emission monitoring of metals based on inductively-coupled plasma optical emission spectroscopy (ICP-OES) in collaboration with Germany instrument provider AMETEK – SPECTRO. The pilot instrument was developed for online determination of trace elements in flue gases of incinerators and power plants.

The ICP-OES is equipped with a modified torch to allow the introduction of flue gas directly into the plasma. Investigated metals were Ni, Hg, V, Al, Na, Ca, Cu, Sn, Pb, Sb, As, Cd and Tl, with limits of detection in the range 0.0004 mg/m^3 to 0.1 mg/m^3 being calculated. Measurements were taken from a UK municipal solid waste incinerator; for the use in coal-fired power plants it was unclear whether detection limits were appropriate. [Clarkson et al. 2003]

The pilot project of Sheffield University was followed by a second test application at the same waste incineration plant. [Pool et al. 2006]

For further product development, a complete assessment of the results of the pilot studies and an assessment of possible markets is pending.
[SPECTRO 2007]

In the USA a semi-continuous monitoring instrument for heavy metal analysis has been developed in the last 10 years, sampling during 15 minutes and analysing the collected sample. The research has resulted in a measurement instrument called Xact CEMS, placed on the market in 2003 by Cooper Environmental Instruments[146].

The instrument uses X-ray fluorescence. It measures vapour and particulate phase metals that have been collected on a reactive filter. Daily upscale, blank and flow checks are automatically conducted.

The system measures with an accuracy of $\pm$ 5 % for concentrations from 10 to > 1000 µg/Nm^3 with a precision of $\pm$ 2 %.

[146] http://www.cooperenvironmental.com

The system analyses simultaneously up to 20 metals, taking measurements all 15 minutes. For this interval, it can not be regarded as a continuous monitoring system.

In early 2007 the instrument has been granted the clean air excellence award of the US EPA and was approved by US EPA to comply with the monitoring requirements of US EPA method 29 for heavy metal analysis (covering Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Hg, Ni, P, Se, Ag, Tl, Zn)[147], except for Beryllium determination. The instrument is able to detect all 12 heavy metals covered by the regulations of the Waste Incineration Directive (Cd, Tl, Hg, Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V). [Cooper 2007]

The system is applied for several years in a municipal waste incinerator and in three hazardous waste incinerators for army waste. In 2007, three additional applications have been ordered for two army waste incinerators and a coal fired power station.

Investment costs are about 125,000 Euro (170.000 US-$) for bottom of the stack applications (without housing). No contact with European instrument providers has been established. No compliance check with European standard methods has been undertaken. [Cooper 2007]

4.6.2.1. Summary on continuous metal measurement instruments

It can be summarized that the measurement techniques for metals other than mercury are still in a pilot stage in Europe and no instrument is available on the European market. No European Standard was developed for continuous mercury measurement.

One continuous monitoring instrument for metals is available on the US market, fulfilling the requirements of US EPA method 29 for metal analysis for all heavy metals listed.

147 http://www.epa.gov/ttn/emc/promgate/m-29.pdf

4.6.3. Continuous mercury measurement instruments

Continuous measurement techniques are available for mercury detection in waste gases since the early 1990s. There are several suppliers on the market, for example:

- DURAG VEREWA “HM 1400”,
- Mercury Instruments “SM 3”,
- SICK MAIHAK (former Perkin-Elmer) “MERCEM”,
- Seefelder Messtechnik “Hg-CEM”,
- Semtech “Hg 2000”, “Hg 2010”
- Envimetrics “Argus-Hg“,
- Tekran “Series 3300”.

In 2007, German Environmental Protection Agency (UBA) has listed the first five suppliers having passed successfully the performance test for continuous measurement instruments, acknowledged by most European authorities.[148] Reliability of several measurement instruments has also been proved or is currently applied for by MCert (Monitoring Certification Scheme of the National laboratory services of UK Environmental Agency).

European Standard for the determination of total mercury in automated measuring systems has been developed. [EN 14884 2005]

4.6.4. Technical issues of continuous mercury measurement

The set up of instruments for continuous mercury measurement is complex as mercury is present in waste gas in different types of bond: as elemental mercury (Hg) and as combined gaseous mercury chloride ($HgCl_2$).

As concentrations in the flue gas of waste incinerating installations are generally in the range of ppb (µg/m^3), special attention must be paid to disturbance of the measurement by effects of adsorption. Therefore recommended materials are tubes of PTFT (Teflon) or glass. Maintenance of the instruments and the execution of performance tests and calibration have to meet high demands to ensure that continuous mercury measurement devices give reliable long term results. Mercury chloride concentration can easily be falsified by reducing agents (e.g. waste gas condensate of SO_3). This effect can be avoided by permanent heating of the measurement tubes. [FKZ 2000]

Measurement equipment consists of a gas sampling probe in the stack and a dust filter, a heated gas sampling duct, a reducing stage and a photometer for elemental mercury detection. Mercury compounds are reduced to elemental mercury in the reducing unit.

[148] http://www.umweltbundesamt.de/luft/messeinrichtungen/moemi14.htm

Two different reduction units are on the market: wet chemical process instruments using liquid reducing agents (e.g. tin (II) chloride) and thermo-catalytic instruments realising the reduction with a heated (gold) catalyst.

Analysers decomposing mercury compounds by a catalyst at elevated temperature have been developed to overcome the problems caused by cross sensitivity towards sulphur dioxide and by wet chemistry. [Hg-CEM 2004]

In general, no serious problems are reported from waste incineration plants. Problems of falsified results have been deleted by using adequate materials and changing material if contamination is detected. [CEWEP 2007]

Performance problems are more likely to be present in co-incineration plants where emission limits for contaminating substances like sulphur oxides are distinctly higher than in waste incineration plants. If waste gases show high sulphur oxide concentrations, measurement materials may be contaminated with substances absorbing gaseous mercury. This effect results in decreased mercury signals leading to the indication wrong (lower) mercury values. If wrong mercury values are detected during performance checks, about 95 % of wrong values are lower than the correct value due to substances polluting instrumentation materials. Besides sulphur oxides, increased emission concentrations of iodine have been determined as responsible factor for wrong (lower) mercury values (occurring in a cement co-incineration plant). [Winkler 2007]

The experience reported from a research project of the German cement industry research institute (VDZ) shows that the particular features of the exhaust gas matrix of cement plants frequently require special instrument modifications for the use in long-term operation in cement plants. By the following measures the instruments can meet the quality requirements, adapted to the specific exhaust gas composition of the emission source:

- a high-flux bypass to minimise the wall effects in excessively long gas sampling ducts
- an increase in the catalyst temperature to prevent poisoning
- the installation of rinsing options to clean the path of the sampled gas from salt-type deposits (e.g. ammonium)
- the modification of the reducing solution in the wet-chemical reducing stage. [VDZ 2006]

Recently a continuous mercury measurement instrument has been tested in a lime plant in Germany. Problems similar to those occurring in cement plants have been found making adaptations of the measurement systems necessary to achieve reliable results. No results are available as the test was not continued. [Düsseldorf 2007]

4.6.5. Standards for continuous mercury measurement

The Technical Committee 264 on air quality of the European Committee for Standardisation (CEN) has developed and validated the European Standard EN 14884:2005 “Determination of total mercury in automated measuring systems”. [EN 14884 2005]

The document is based on EN 14181 (general requirements on automated measuring systems). It includes specific requirements for quality assurance and performance testing to prove compliance for mercury emissions from sources with an emission limit value of 0.5 mg/m^3.

In the introduction of the standard it is clearly stated that it depends from the type of process and from the sampling location whether an automated measuring systems is able to comply with the requirements of total mercury determination. It stresses that the document was first of all elaborated for emissions of waste incineration plants but from a technical point of view it may be applied for other processes, too.

For performance testing, compliance of the instrument signal has to be verified using different mercury concentrations. For this purpose the German cement industry research institute has developed a specific test gas generator, as mercury test gases have a shelf life of several weeks only which hinders its use for regular on site monitoring of measurement instruments.

The test gas generator provides elemental mercury concentrations from 2 µg/m^3 up to several hundred µg/m^3. By this, defined concentrations of elemental mercury can be produced in dependence on the temperature and the resulting equilibrium partial pressure. A special evaporator is used for the on-site generation of test gas mixes that contain combined mercury chloride. The testing of the measuring instrument with both elemental mercury and mercury compounds enables to prove that the photometer, the reducing stage and the measuring system as a whole perform properly. [VDZ 2006]

4.6.6. Application of continuous mercury measurement

Continuous measurement of mercury is required in waste incineration plants in Austria and in Germany since 1990. Continuous mercury measurement in all waste incineration and co-incineration plants is required in Austria since 2002 and in Germany since 2003.

In Germany this requirement includes the possibility to allow exemptions if it has been proven that mercury emissions are not possible or evidence is proven that less than 20% of the emission limit values is achieved (for all waste incineration and co-incineration plants 0.05 mg/m^3 is set as half-hour average value and 0.03 mg/m^3 as daily average value[149]). No specification is determined on how to evidence has to be proven that less than 20% of the ELV is achieved.

In Austria continuous mercury measurement is not necessary if it is proven that mercury concentration of waste input is less than 0.5 mg/kg [with 25 MJ/kg[150] net calorific value] and if it has been proven that the measurement values are lower than 20 % of the emission limit value.[151]

Continuous measurement techniques for the detection of mercury are installed for many years now in a high number of plants, e.g. in Germany in more than 35 incinerators for municipal waste incineration and in about 15 waste wood incinerators. [Gebhardt 2005], [CEWEP 2007]

In the cement industry, continuous measurement of mercury is practised in 25 plants of EU 27 (not allocated in detail). [CEMBUREAU 2007]

4.6.7. Costs of continuous mercury measurement

Investment costs for continuous mercury measurement instruments are reported with 45-50,000 Euros. [Seefelder 2007], [Mercury Instruments 2007], for installation in power plants up to 60,000 Euros have been reported [German Plant 2007]. Calibration costs account for about 5000 € for personal and about 1500 € for 15 laboratory analyses.

Assuming installation costs of 42,500 Euros, a depreciation of 10 years and an interest rate of 10 %, yearly investment costs sum up with ~7,500 Euro. Calibration is needed at least all 5 years, thus yearly calibration costs sum up with about 1,300 Euros. Additional costs for maintenance of about 1,000-1,500 Euros per year are assumed.

[149] 0.05 mg/m^3 as daily average value may be permitted for cement and lime industry if a daily average value of 0.03 mg/m^3 is exceeded due to the mercury content of the raw material

[150] if the net calorific value of the waste differs from 25 MJ/kg the maximum mercury content of the waste is defined by the net calorific value multiplied with 0.02 mg/MJ.

[151] Authorities may permit latest until 28th December 2007 continuous mercury measurement for test and trial periods of maximum 2 years for optimisation of the test instrument. If the measurement values of the test and trial period are not suitable for compliance check, a periodic measurement has to be undertaken.

Total costs for continuous mercury monitoring are estimated with about 10,000 Euro per year.

4.6.8. Conclusions

Equipment for continuous measurement of other heavy metals than mercury is still under development.

Equipment for continuous measurement of mercury is available, applied for about 10 years at waste incineration plants and in cement industry. The systems are recognized and recommended by public authorities [Impel 2005] and acknowledged by independent measurement institutes.

Continuous measurement of mercury is required in waste incineration plants in Austria and in Germany since 1990. Continuous mercury measurement in all waste incineration and co-incineration plants is required in Austria since 2002 and in Germany since 2003. Reference to the EN standard 14884:2005 on automatic mercury measurements can be made.

There are no technical restrictions hindering the inclusion of requirements on continuous mercury monitoring systems for waste incineration plants and cement plants.

Little experience is available on the continuous mercury measurement application in other waste incinerating sectors than dedicated waste incinerators and cement industry.

4.7. Analysis of impacts of introducing continuous monitoring of heavy metals

4.7.1. Problem definition

The feasibility study on continuous monitoring of heavy metals has concluded that

- continuous measurement of heavy metals other than mercury is not available,
- instruments for continuous measurement of mercury are available,
- continuous measurement of mercury in waste incineration and co-incineration plants is required by a few Member States (Austria since 2002 and Germany since 2003),
- reference to a EN standard on automatic mercury measurement can be made,
- instruments for continuous measurement of mercury have been applied in waste incineration and cement industry plants for about 10 years, but
- little experience was gained from other sectors of waste co-incineration.

At present, the Waste Incineration Directive requires only a periodic measurement of mercury emissions. However, Article 11 (13) on measurement requirements asks the Commission to decide the date from which continuous measurements of the air emission limit values for heavy metals shall be carried out, "as soon as appropriate measurement techniques are available within the Community".

Mercury is a persistent substance. Mercury and its compounds are highly toxic to humans, ecosystems and wildlife. High doses of mercury can be fatal to humans. In soil, mercury retards microbiological activity. Mercury is a priority hazardous substance under the Water Framework Directive. Mercury pollution is not only a local but a global, diffuse and chronic problem.

In the environment, mercury can change into methyl mercury. Methyl mercury is the most toxic form as it easily passes the blood-brain barrier with the effect of inhibiting mental development. It also passes readily the placental barrier and inhibits mental development before birth. Moreover, low doses are suspected to have harmful effects on the cardiovascular, immune and reproductive systems. [COM Mercury 2005], [EEB Mercury 2005]

Within the European Union, atmospheric mercury ranges has been documented from remote areas with 0.001–6 ng/m^3, from urban areas with 0.1–5 ng/m^3 and from industrial areas with 0.5–20 ng/m^3 [WHO 2000]. Most people in central and northern Europe show bio indicators of exposure below internationally accepted safe levels for methyl mercury, but most people in coastal areas of Mediterranean countries and about 1-5% of the population in central and northern Europe are around international accepted safe levels, and large numbers among Mediterranean fishing communities and the Arctic population exceed the levels significantly [COM Mercury 2005].

Waste incineration and co-incineration is a potential source of mercury emissions, especially due to incineration of hospital waste and electronic waste. These emissions may occur as peak emissions and may last several hours up to several days due to memory effects in the plant. [Gebhard 2005]

The Reference Document on Best Available Techniques (BREF) for Waste Incineration defines BAT associated emission levels of 0.001-0.03 as half-hour average value and 0.001-0.02 mg/m^3 as daily average value for continuous measurement; for periodic measurement the level is set as < 0.05 mg/m^3 (with split views defining the level with 0.001-0.03 mg/m^3).

The BREF document states that "adsorption using carbon based reagents is generally required to achieve these emission levels with many wastes - as metallic Hg is more difficult to control than ionic Hg. The precise abatement performance and technique required will depend on the levels and distribution of Hg in the waste. Some waste streams have very highly variable Hg concentrations – waste pre-treatment may be required in such cases to prevent peak overloading of flue gas control system capacity."

4.7.2. Objective of the proposal

The objective of the proposal is to assess the effects of implementing continuous monitoring of mercury according to the action required from the Commission by Article 11 (13) of the Waste Incineration Directive, to implement continuous monitoring of heavy metals as soon as appropriate measurement techniques are available.

Several cases have shown that a continuous measurement of mercury is able to detect peak emissions. Detection is the pre-condition to take adequate measures for stopping these emissions (e.g. measures like research for mercury source detection or plant cleaning).

Detection of peak emissions can lead to improved input control and helps promoting prevention measures to avoid the input of mercury containing waste.

The proposal also supports the targets of the Commission‘s Strategy on Mercury (COM 2005/20), the aims of the Heavy Metals Protocol to the UNECE Convention on Long Range Transboundary Air Pollution [UNECE 1998] and follows the major aims of the Waste Incineration Directive, of preventing or limiting emissions into air.

For the control of proper operation of mercury abatement systems no other monitoring parameter is able to show the performance other than mercury itself.

4.7.3. Procedural aspects

The objectives of the Commission's Strategy on Mercury may be fulfilled by different policy options.

As agreed with the Commission Services, this assessment covers the options "Business as usual" and "Amendment of the Waste Incineration Directive by implementing continuous mercury monitoring".

Data has been used from the feasibility study on heavy metal monitoring (see chapter 4.6), as well as from literature study, from consultation of instrument suppliers, public authorities, industry associations and individual plants.

4.7.4. Policy options

To achieve the objective of reduced mercury emissions, the following policy options will be analysed:

1) Option 1 (business as usual). The requirements of the Waste Incineration Directive are not changed regarding mercury monitoring.
2) Option 2. Amendment of the Waste Incineration Directive 2000/76 (Amendment of the Waste Incineration Directive including a general requirement of continuous mercury emission monitoring). The continuous measurement of Hg may be omitted if evidence can be proved that the waste will under no circumstances include mercury. The continuous measurement of Hg may also be omitted if waste can be characterized as homogeneous, a static coke bed filter or an activated coke injection systems is installed and performance checks with continuous monitoring systems have proven evidence during 6 months of regular plant operation that 20% of the emission limit values is not exceeded.

It is assumed that 2013 is the earliest possible year for implementing new requirements of the Waste Incineration Directive. Therefore, also for option 1, 2013 is regarded as year of comparison of options.

4.7.5. Identification of priority impact categories

The identification of impact categories and the screening of impacts relevant to each stakeholder group (business, consumers, public authorities and the environment) came to the following result:

1) Economic impacts: Most relevant impact categories may be competitiveness, competition in the internal market, trade and investment flows, operating costs, administrative costs, consumers and households and public authorities. Little relevance is seen for the categories specific regions, innovation and research. No relevance of the categories conduct of business, property rights, third countries, international relations and macroeconomic environment.

2) Environmental impacts: Most relevant impact categories may be air and water quality, environmental risks, soil quality and animal health. Less relevance is seen for food and feed safety, biodiversity, flora and fauna. No relevance is seen for the categories climate, use of energy, renewable or non-renewable resources, landscapes, land use, waste production, waste recovery and mobility (transport modes).

3) Social impacts: Most relevant impact categories may be public health and safety, workers' health, good administration, public confidence in incineration and co-incineration of waste, employment and labour markets. Categories without relevance are expected to be standards and rights related to job quality, social inclusion and protection of particular groups, equality of treatment and opportunities, non-discrimination, private and family life, personal data, governance, participation, access to justice, media and ethics, crime, terrorism and security, access to and effects on social protection, educational systems.

4.7.6. Affected stakeholder groups

4.7.6.1. Waste incineration and co-incineration industry

At present, two Member States have implemented requirements on continuous mercury monitoring with different specifications on the possibility to grant exemptions.

In Austria, all plants falling under the Waste Incineration Directive are subject to the general requirement on continuous mercury monitoring. This affects for example 9 dedicated waste incineration plants and 51 co-incineration plants. No information is obtained on how many exemptions from continuous measurement have been granted due to evidence prove that waste input does not exceed certain mercury levels or due to evidence prove that the emissions do not exceed 20% of the emission limit values. No general rule is known on proving evidence that the emissions do not exceed 20% of the emission limit values.

In Germany, all plants falling under the Waste Incineration Directive are subject to the general requirement on continuous mercury monitoring. Of the plants falling under the Waste Incineration Directive, about 50% of municipal waste incinerators (35 plants) have installed continuous measurement systems, all waste incinerators for contaminated waste wood (about 15 plants), most cement plants co-incinerating waste (about 25) and all coal power stations co-incinerating waste (1). If option 2 is implemented, about 35 municipal waste incineration plants and a few cement plants will have to prove evidence that less than 20% of the emission limit value is achieved, applying continuous mercury measurement during half a year of regular plant operation, as the current exemptions are not based on this evidence prove (a general rule for evidence prove does not exist and evidence is generally proved by a determined number of periodic measurements).

According to the data that became available during data collection 1400 incineration and co-incineration plants were identified in total. The largest group are dedicated waste incinerators (40%) followed by combustion plants (15%) and cement plants (9%). Taking into account that some stakeholders did not deliver information and concluding from expert interviews and literature research it is estimated that a total of 1800 plants incinerate or co-incinerate waste in Europe[152].

- Most plants are not yet subject of continuous mercury measurement. Implementation by option 1 depends on Member State's policy. It is assumed that about 10 % of the installations will install continuous mercury measurement under option 1 until 2013.
- All installations currently not providing of continuous measurement of mercury would be affected by option 2 in 2013.
- None of the options will affect plants in Germany and Austria as a general requirement on continuous mercury measurement is in force.
- Member States authorities, waste incineration associations and Gebhardt [2005] have indicated that continuous mercury measurement is executed at least in 38 dedicated waste incineration plants (35 plants in Germany, 1 in Finland, 2 in Portugal, 1 in Sweden).
- CEMBUREAU indicated that 25 cement plants measure mercury continuously (including data from Norway and Switzerland), EULA reported that 4 lime plants measure mercury continuously; one German power plant has reported to measure mercury continuously (see cost benefit analysis in chapter 3).
- Summing up, about 70 plants have reported to measure mercury continuously in 2006. Assuming that a maximum of 30 additional plants was not reported, the total number of installations under the Waste Incineration Directive measuring mercury continuously is considered to be about 100 out of 1,800 installations (5.5 %).
- The experience of Germany has shown that about 50% of the dedicated waste incineration plants have been able to prove that emission levels are below 20% of the emission limit value. As this was proved generally without continuous monitoring but with a relevant number of periodic measurements, it is assumed that only 30% of the installations will be able to prove evidence when applying continuous monitoring systems.
- Based on this, it is assumed that in EU 27 a similar share of dedicated waste incinerators will be able to obtain exemptions from the general requirement.
- Taking into account that about 50 % of the installations will be able to apply successfully for exemptions on continuous mercury monitoring (similar to the percentage of dedicated waste incinerators operating with

[152] It has to be taken into consideration that some data uncertainty exists.

monitoring exceptions on continuous mercury monitoring in Germany), about 850 installations currently falling under the Waste Incineration Directive will be subject of option 2 (Amendment of the Waste Incineration Directive including a general requirement of continuous mercury emission monitoring).

- If 40% of a total of 1800 plants operating under the Waste Incineration Directive are dedicated waste incinerators, this results in 720 plants. If 30% of these plants are able to prove that emission levels are below 20% of the emission limit value, this makes about 220 plants that will only apply continuous mercury monitoring during half a year to prove evidence of low emission levels. Another 500 plants will install permanently continuous mercury monitoring instruments.

- For installations of industries like cement plants, lime plants and large combustion plants that may or may not co-incinerate waste, it is assumed that due to economic advantages of waste incineration only about 5 % of cement plants will not co-incinerate waste.

- In EU 25 there are about 254 cement plants with 380 kilns [CEMBUREAU 2006-3]. Data for Romania and Bulgaria is estimated with about 6 cement plants and 10 kilns, resulting in a total number of about 260 cement plants and 390 cement kilns in EU 27. 5 % amount with about 20 plants not co-incinerating waste in a future, being subject of re-definitions of mercury measurement in BREF document (option 1), 95 % will be subject of the Waste Incineration Directive (option 2) comprising 240 plants, of which 25 have already installed continuous mercury monitoring, thus 205 cement plants may have to install additional mercury measurement if not being able to obtain derogations. It is assumed that about 50 % of the plants will be able to obtain derogations, thus 102 cement plants in EU 27 are covered by option 2.

- Additionally to waste incinerating or co-incinerating industries, suppliers and maintainers of mercury measurement instruments are affected.

4.7.6.2. Consumers and households

Consumers and households are only affected if waste disposal prices will rise.

4.7.6.3. Public authorities

Public authorities are concerned as far as they are involved in monitoring (evaluation of reports).

4.7.6.4. Environment

Air, water, soil and wildlife is mainly concerned.

4.7.7. Analysis of impacts – Option 1: Business as usual

4.7.7.1. Possible development when implementing option 1

Most installations for waste incineration and co-incineration are subject of Directive 96/61 requiring the consideration of best available techniques (BAT).[153]

At present, the BAT reference documents relevant for the waste (co-)incinerating industries (waste incineration, cement and lime manufacturing industries, large combustion plants) do not define continuous mercury measurement as BAT. [BREF C+L 2000] [BREF LCP 2003]

It was suggested for the revision of the BREF on waste incineration (published in 2005) to investigate "further experiences with continuous emissions monitoring for mercury, with a view to establishing BAT conclusions where possible". [BREF WI 2005]

It is assumed that about 10 % of all installations (~180) will install continuous measurement under option 1 until 2013.

4.7.7.2. Economic effect of option 1

The implementation of option 1 (business as usual) has negative economic effects for industry for those plants where continuous monitoring has to be realised; thus no level playing field is achieved. Different requirements will result from different Member State regulations. Additionally, BAT definitions on continuous mercury monitoring in BREF documents may lead to different inclusion of these BAT definitions in permits (regarding inclusion as such and regarding time of inclusion).

Hence, investment costs of about 50,000 Euros per instrument will not be implied at all installations at the same time. This will have a negative effect on internal competition, although considered as relatively small due to the relatively small investment compared with regular turn-over of several million Euros.

Under "business as usual", in 2013 it is expected that about 10 % of the installations will have implemented continuous mercury measurement (~180 plants). Currently, at least about 40 installations in Germany and Austria have installed continuous mercury measurement (total of max. 100 plants in EU 27), thus an investment of about 4 m Euros is related with option 1 until 2013.[154]

No effects on consumers and households is expected because annual costs related with continuous mercury monitoring of about 10,000 Euros are equivalent to about 0.07 Euro per tonne of waste (for a plant capacity of 150,000 tonnes) or about 0.04 % of a consumers disposal price for waste collection and incineration of about 160 Euros per ton.

[153] Due to economy of scale there are only few dedicated waste incinerators and few cement plants not subject to the IPPC Directive.

[154] Not taking into account that some installations have more than one stack and therefore need more than one equipment.

No effect on public authorities is expected as evaluation of monitoring results is similar to the effort of periodic measurements.

4.7.7.3. Environmental effects of option 1

It is assumed that by implementing option 1, in 2013 about 10 % of all installations under the Waste Incineration Directive will have to measure mercury continuously due to legislative requirements, due to local ambient air pollution or because continuous monitoring is considered as BAT.

Emissions of mercury arise e.g. from waste input like mercury switches, fluorescent tubes and thermometers. If peak emissions are not detected, waste gas abatement systems using activated coke can not be adapted to the peak. In some installations, not even activated coke systems are installed and casually no need for such waste gas abatement may have been detected by periodic measurement. In extreme cases, several kilograms of mercury are emitted by the installation and lead to contaminations (and related high emission levels) during the following days. . Weisweiler/German, a peak emission of about 350 kg mercury input to the municipal waste incinerator was detected by continuous measurement. [Gebhardt 2005] The total amount of such undetected mercury emissions can not be quantified nor estimated because these emissions occur on varying levels and as short term or as long term peaks.

In some cases it has been possible to stop increasing mercury peaks by immediate supply and injection of sulphur activated coke. [Carbon Service 2007] Such increasing mercury emissions will not be detected in 90 % of the installations by 2013.

Non-detected, non-reduced mercury emissions may have negative effects on eco-systems and wildlife. Because of lack of data, the amount of emissions can not be quantified.

No cross-media effects are expected by implementing option 1.

4.7.7.4. Social effects of option 1

Peak levels of mercury emissions of the respective plants can not be detected as long as only periodic instead of continuous measurement of mercury is required. This can lead to relevant mercury emissions.[155]

Non-detected, non-reduced mercury emissions may have negative effects on human health (can not be quantified due to lack of data on peak emissions).

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[155] A study on 35 German municipal waste incinerators with continuous monitoring has shown that in 50% of the plants the emission limits have been exceeded for short times. The study has also shown that exceedances of mercury emission were reduced when detected (due to more information of waste suppliers and improved input control). The most severe case was detected at the dedicated municipal waste incinerator of Weisweiler/Germany emitting about 8 kg mercury per year during regular operation. In 2001, a single peak emission has lead to a mercury emission of about 35 kg. [Gebhardt 2005]

High risk of mercury emissions leads to low acceptance of waste incineration. It is assumed that implementing option 1 (business as usual) will reduce such risks in about 10 % of the installations under WID; in about 30 % of the installations it is assumed they are able to perform with low mercury emissions (due to low mercury input in waste). In the remaining 60 % of installations a relevant risk is maintained.

4.7.8. Analysis of impacts – Option 2: Implementation of the requirement of continuous mercury monitoring with the possibility to grant exemptions if no/low emissions can be expected

4.7.8.1. Description of the actions to be taken under option 2 - implementing continuous mercury monitoring requirements

Option 2 includes the determination that continuous mercury measurement will come into force on 1.1.2013. Latest at this date, plant operators falling under the Waste Incineration Directive will have to invest in automatic measurement instruments for continuous mercury monitoring, if they are not subject to one of the exemption rules.

Plant operators and authorities will be able to use this information to perform permanent compliance checks on mercury emissions. Plant operators and authorities will be able to react with adequate measures on peak emissions.

Plant operators will have to invest in measurement systems or will have to prove that the waste input under no circumstances includes mercury or (under the condition that the waste is considered as homogenous and a static coke bed filters or an activated coke injection systems is installed) will have to prove during 6 months of regular plant operation with continuous monitoring systems that 20 % of the emission limit values is not exceeded.

Automatic measurement instruments will have to be calibrated according to standard EN 14181 on quality assurance of automated measuring systems. The standard requires calibration at least every 5 years, performing at least 15 valid parallel measurements, uniformly spread both over at least 3 days and over each of the measuring days of normally 8 to 10 hours.

4.7.8.2. Economic impact of option 2

Economic impacts will be relevant for all plants that can not prove to be subject of exemptions.

The sector of dedicated waste incineration is expected to cover 220 plants able to prove low mercury emissions. Installation of continuous mercury measurement systems for 6 months implies costs of about 70 % of the total investment costs of 40-50,000 €156, thus 28-35,000 €, because after 6 months the equipment is contaminated and dirty. Additionally, single calibration costs arise

[156] Does not include mounting cost which depend on plant design.

(5,000 € for personal and 1500 € for 15 laboratory analysis). Assuming total investment costs of 35,000 € for a 6 month installation, the total investment for all 220 plants subject to a derogation will comprise about 7.7 m Euros.[157]

Assuming a gate fee of about 100-160 € per tonne of waste, the investment accounts for 0.2-0.4 % of the turn over for a plant capacity of 150,000 tonnes per year, 0.1-0.2 % of a large plant (300,000 tonnes capacity) and about 0.6-1.2 % of a small plant (50,000 tonnes capacity).

Based on these figures, relevant effects on internal competition are only expected for small waste incineration plants being subject of the derogation.

By implementing option 2 it is estimated that about 500 dedicated waste incineration plants will permanently have to install a measurement systems for continuous mercury monitoring (compare chapter 4.7.6). Assuming investment costs of 50,000 € per unit[158], the total investment in EU 27 will comprise 25 m Euros.

Based on a depreciation of 10 years and capital costs of 10 %, additional costs for maintenance (including annual function test) and calibration (all 5 years), yearly costs related with the permanent implementation of the continuous mercury measurement result in about 10,000 €. No relevant cost savings can be expected by omitted periodic mercury measurement because mercury measurement is generally done in combination with other heavy metal measurement (which has to be continued), and omitted costs for at least two mercury analyses are about 200 Euro per year.

Assuming a gate fee of 100-160 Euros per ton, yearly costs of about 10,000 € account for 0.04-0.07 % of the turn over of an average plant size of 150,000 tonnes of waste input capacity per year, 0.02-0.04 % of a large plant (300,000 tonnes capacity) and about 0.08-0.15 % of a small plant (50,000 tonnes capacity). Treatment costs increase by implementing continuous mercury monitoring about 0.2 Euro per tonne in small plants and 0.03 Euro per tonne in large plants, equivalent to 0.02-0.1 %.

Resulting from these figures, no relevant effect on international competition is expected (which is small anyway due to relative small amount of waste export for disposal or recovery).

For cement industry it is assumed that about 102 installations will have to invest in permanent installation of continuous monitoring systems (compare chapter 4.7.6) comprising about 50,000 Euro per unit. This results in about 5.1 m Euro in EU 27.[159]

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[157] Not taking into account that some installations have more than one stack and therefore need more than one equipment.

[158] Does not include mounting cost which depend on plant design.

[159] Not taking into account that some installations have more than one stack and therefore need more than one equipment.

Cement industry has gate fees of about 40-60 Euros per tonne of waste, incineration different amounts of up to 100 % of regular fuel substitution, resulting in about 80 Euros of benefit per tonne of waste compared with regular fuel supply.

A medium plant size is 1,500 tonnes of clinker per day, thus about 480,000 tonnes a year at 320 days of production. Assuming a cement price of 60 Euros and a clinker share of 85 %, a turn-over of 24.5 m Euros per year is achieved. Mercury measurement costs of 10,000 Euros (assuming a depreciation of 10 years and capital costs of 10 %) result in 0.04 % of the turn-over. Additional monitoring costs result in additional costs of 0.02 Euro per tonne of clinker (about 0.03 %).

In general, little effect on internal competition is expected as requirements are valid for all installations under the Waste Incineration Directive. Based on the figures above, relevant effects on internal competition are only expected for small dedicated waste incineration plants.

Small disadvantages for industries co-incinerating waste are expected compared with other industries of the same sector without waste co-incineration (or industries outside EU 27 with waste incineration but without continuous mercury monitoring requirement). These effects are compensated by relatively high economic profits of waste reception compared to regular fuel expenses (profits of around 80 Euros per tonne of fuel compared to additional measurement costs of 0.10 Euros per tonne of waste incinerated if 100,000 tonnes of waste is assumed).

Once installed, half-hour values of the measurements can be delivered automatically to the plant operators (and in some cases to the competent authorities), and annual summaries on emissions are automatically reported by the system; therefore additional administrative costs are seen as irrelevant in industry as well as in authorities.

No effects on consumers and households are expected because annual costs related with continuous mercury monitoring of about 10,000 Euros are equivalent to about 0.07 Euro per tonne of waste (for a plant capacity of 150,000 tonnes) or about 0.04 % of a consumers disposal price for waste collection and incineration of about 160 Euros per ton.

Besides the described effects on waste incineration and co-incineration industry, implementing option 2 will have a direct positive economic effect on measurement instrument suppliers due to broader markets (providers mainly originate from Germany and USA). This may stimulate research and development, positive especially because research in co-incinerating sectors with difficult waste gas matrices is needed, e.g. lime industry.

4.7.8.3. Environmental effects of option 2

Non-detected, non-reduced mercury emissions can have a negative effect on eco-systems and wildlife. . As stated above, single peak emissions have been detected by continuous measurement systems, like about 350 kg mercury input to the municipal waste incinerator of Weisweiler/German. [Gebhardt 2005] The total amount of such undetected mercury emissions can not be quantified nor estimated because these emissions occur on varying levels and as short term or as long term peaks.

Implementing continuous mercury monitoring by 1.1.2013 leads to reduced risk of exceeding emission limit values and has a potential for reducing the emissions resulting from emission peaks that are otherwise are not detected.

Cases of relevant mercury input into waste incinerators have been reported by Gerhardt [2005], showing that in cases of continuous measurement of mercury it was possible to take action to reduce these peaks. Similar situations have been reported by activated coke suppliers, having experienced effective reactions on peak emissions by injection of sulphur activated coke [Carbon Service 2007]. Such reactions are possible in all installations under the WID after 2013 if option 2 is implemented.

Cross-media effects are expected by implementing option 2.

4.7.8.4. Social effects of option 2

Peak levels of mercury emissions can not be detected as long as periodic measurement instead of continuous measurement of mercury is required. This may lead to relevant mercury emissions that can be reduced if detected.[160] The effect is difficult to quantify due to the high level of uncertainty of current mercury peak emissions.

However it can be stated that implementing continuous mercury monitoring will lead to reduced risk of exceeding emission limit values and has a potential for reducing emissions resulting from peaks that are otherwise are not detected.

Non-detected, non-reduced mercury emissions may have a negative effects on human health (can not be quantified due to lack of data on peak emissions).

[160] A study on 35 German municipal waste incinerators with continuous monitoring has shown that in 50% of the plants the emission limits have been exceeded for short times. The study has also shown that exceedances of mercury emission were reduced when detected (due to more information of waste suppliers and improved input control). The most severe case was detected at the dedicated municipal waste incinerator of Weisweiler/Germany emitting about 8 kg mercury per year during regular operation. In 2001, a single peak emission has lead to a mercury emission of about 35 kg. [Gebhard 2005]

As shown by Gebhardt [2005], peak emissions are regularly detected by continuous monitoring systems, significantly high peak emissions have happened, and positive effects were observed due to increased measures of preventing mercury input to the plants (increased input control, increased information on possible mercury sources at waste suppliers and society).

Increasing public acceptance of waste incineration is expected by implementing continuous mercury monitoring. Apart from PCDD/F, mercury is the parameter of highest attention to the public. Therefore more acceptance is expected if related risks are reduced and it can be assured that adequate action can be taken in case of peak emissions.

No negative impact on workers' health is expected as operators do not come in contact with samples of measurement instruments.

4.7.9. Comparison of options

The implementation of option 1 (business as usual) implies the continuation of a high level of uncertainty about mercury peak emissions in about 90 % of all installations. This risk is significantly reduced by implementing option 2.

Economic impacts on affected industries are relatively small in both options and significant only for small waste incineration plants.

The implementation of option 2 leads to reduced risks. Compared to option 1, it implies a higher potential for reducing the damage of human health, environment and wild life.

Whereas with option 1 it is expected that in 2013 a share of 10 % of the installations is able to adequately react on peak emissions, in option 2, waste gas abatement efficiency is permanently controlled. Injection of activated coke can be adapted to needs.

By implementing option 2, the same requirements will be set for all installations under the Waste Incineration Directive on 1.1.2013. By implementing option 1 the application of continuous mercury measurement would depend from national policy, and individual permit decisions.

Relevant cross-media effects are not related with none of the two options.

4.8. Technical feasibility and costs of implementing a NOx emission limit value of 500 mg/m³ for existing cement kilns

4.8.1. Introduction

The review clause in Article 14 of the Waste Incineration Directive asks for assessing the economic and technical feasibility for existing cement kilns, as referred to in the footnote to Annex II.1.1. ("C - total emission limit values"), of respecting the NOx emission limit value for new cement kilns set out in that Annex.

The footnote extends the application of the NOx limit value for existing plants also to those plants starting co-incineration after 28 December 2004 if they are operating with a permit in accordance with existing Community legislation.

Annex II.1.1 of the Waste Incineration Directive determines the following NOx ELVs for cement plants:

Table 90: NOx emission limit values for cement plants of the Waste Incineration Directive, Annex II.1.1.

Pollutant	C [mg/m³] at 273 K, 101.3 kPa, 10 % O_2, dry gas
NOx for existing plants	800
NOx for new plants	500 (1)

(1) For the implementation of the NOx emission limit values, cement kilns which are in operation and have a permit in accordance with existing Community legislation and which start co-incinerating waste after the date mentioned in Article 20 (3) are not to be regarded as new plants.[161]

Until 1 January 2008, exemptions for NOx may be authorised by the competent authorities for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value for NOx of not more than 1200 mg/m³.

This chapter 4.8 mainly deals with the assessment of the technical feasibility of applying the 500 mg/Nm³ limit value also to existing cement plants co-incinerating waste, and looks at the costs of the associated measures needed to achieve this (part 4.8.8).

A more extensive impact analysis of implementing an amended emission limit value is presented in the subsequent chapter 4.9.

[161] Article 20 ("Transitional provisions") of the Waste Incineration Directive: (3) Stationary plant or mobile plants whose purpose is the generation of energy or production of material products and which are in operation and have a permit in accordance with existing Community legislation where required and which start co-incinerating waste not later than 28 December 2004 are to be regarded as existing co-incineration plants.

4.8.2. Techniques of NOx reduction in cement plants

A variety of techniques have been developed in order to reduce NOx emissions from cement kilns. These techniques comprise the following measures and related reduction efficiencies [BREF C+L 2000], [Austrian EPA 2004], [Austrian EPA 2005], [CEMBUREAU 2006-1], [Schäfer/Hoenig 2006], [UBA 2007]:

- Primary measures to reduce NOx formation at the source:
    - automatic process and combustion control systems by monitoring NOx levels: reduction efficiency can not be generalized
    - flame cooling (but additional heat required for water evaporation, increase of CO_2): reduction efficiency 0-35% [CEMBUREAU 2006-1]
    - low-NOx burners (injection through concentric tubes): reduction efficiency 0-35% [CEMBUREAU 2006-1]
    - choice of the raw material (addition of mineralisers like calcium fluoride to reduce the sintering zone temperature but limited by a possible increase of HF emissions): reduction efficiency 10-15% [CEMBUREAU 2006-1]
    - choice of the fuel (NOx reduction effects from using waste like e.g. bone meal has been reported without specification of reduction rates): reduction efficiency can not be generalized
    - restricted to long kilns: mid-kiln firing creating reduction zones (using slow burning waste fuels like tyres intermittently in the mid of long kilns, supplied once per kiln revolution): reduction efficiency 20-60% [CEMBUREAU 2006-1], [ENVIRON 2004]
    - restricted to preheater/precalciner kilns: staged combustion mainly using specially designed precalciners (first: main burner, second: kiln inlet burner, third: specially designed precalciners, forth: re-feeding of remaining tertiary air into the system): reduction efficiency 10-50% [CEMBUREAU 2006-1]
- Secondary measures reducing NOx by a chemical reaction with a reducing agent (ammonia water or urea) injected into the waste gas stream at a suitable temperature:
    - SNCR: selective non-catalytic reduction (reduction by reducing agents only), reduction efficiency 30-80% at preheaters/precalciners, 35% at grate preheaters without secondary firing [CEMBUREAU 2006-1]
    - SCR: selective catalytic reduction (reduction by reducing agents and by catalyst): reduction efficiency 40-95% [Leibacher et al. 2006]
- Combination of primary and secondary measures: reduction efficiency 30-70% [Bodendiek 2004]

The table below presents the number of full-scale installations with NOx abatement techniques known by CEMBUREAU and updated (where indicated) with additional information. The table comprises cement kilns with and without co-incineration of waste.

Table 91: Full-scale installations with NOx abatement techniques currently known

Technique Country	Flame cooling	Mineralised clinker	Staged combustion	SNCR	SCR
Austria	3		2	3+2 (3)	
Belgium					
Bulgaria					
Cyprus					
Czech Republic				2 (3)	
Denmark		2			
Estonia					
Finland					
France	19		1+6 (2b)	3+12 (2b) + 6 (4)	
Germany	1*		7+1*	33 + 1*	1 (1a)
Greece			1		
Hungary				3	
Ireland			1	2 (5)	
Italy	2		7	16 (1b)	1 (2a)
Latvia					
Lithuania					
Luxemburg					
Malta	no cement industry	no cement industry	no cement industry	no cement industry	no cement industry
Poland			9		
Portugal	6			4	
Romania					
Slovenia					
Slovakia					
Spain		4	2	3+5 (pilot phase)	
Sweden				3	
The Nether-lands				1	
United Kingdom			1	6 (4)	
Total	**35**	**8**	**40**	**108**	**2**

(1a) Reported in operation (in 2000-2005; additional SNCR technique in operation since 2006*)
(1b) Reported in operation but reporting still lacking
(2a) Put in operation June 2006*
(2b) Scheduled for commissioning end of 2006
(3) 2 in pilot phase
(4) Recently put in operation
(5) Scheduled for commissioning 2007

[CEMBUREAU 2006-1], * additional Ökopol research at plant operators in 2007

4.8.3. Technical feasibility of NOx emissions below 500 mg/m^3 using only primary measures

The results of several investigations on the use of only primary measures in the main firing system show that for most plants it is not possible to guarantee NOx emission levels of 500 mg/m^3. In most cases it can not be avoided that this emission level is occasionally exceeded for short time periods. [Hoenig et al 2001], [Bodendiek/Hoenig 2006], [Schäfer/Hoenig 2006]

In specific kilns where secondary measures are difficult to apply (long kilns and/or wet kilns), mid-kiln firing can achieve NOx reductions up to 60 % [ENVIRON 2004].

A high reduction efficiency (up to 50%) can also be achieved with staged combustion, but the use of this technique is restricted to plants with several combustion stages, thus to kilns with preheaters/precalciners.

Staged combustion is difficult to apply to cyclone preheater plants without precalciners. A tertiary air ducting and calciner system may be installed providing about 10-25% of the total heat; however this is not sufficient to obtain reliable emission levels below 500 mg/m^3.

The principle of staged combustion is that the first combustion stage in the kiln outlet provides optimum conditions for the clinker process; the second combustion stage produces a reducing atmosphere at high temperature, reducing NOx into N_2. This leads to less NOx emissions from the first combustion stage and also reduces NOx generation at the third combustion stage where the fuel for calcining is added.

NOx emission levels below 500 mg/m^3 can only be achieved by staged combustion using fuels that provide a high reactivity and a high share of volatile substances, like lignite, plastic waste, and animal meal. CO emission levels may increase, especially if residence time in the plant is short and combustion is not optimised.

Lower NOx emission levels than 500 mg/m^3 may be obtained but run the risk of increased CO levels and the risk of operational problems due to increased build-ups in kilns and calciners. [Bodendiek 2004], [Bodendiek/Hoenig 2006].

Nevertheless, few kilns have been able to control their NOx emissions safely below 500 mg/Nm^3 by using only primary measures. [UBA 2006], [UBA 2007]

CEMBUREAU has reported levels of less than 500 mg NOx/m^3 from two installations which were achieved with staged combustion [CEMBUREAU 2006-1].

4.8.4. Technical feasibility of NOx emissions below 500 mg/m^3 using SNCR

The BREF for the Cement and Lime Manufacturing Industries, published in 2000 and based on data reported until 1999, defines BAT associated NOx emission levels with a range of 200-500 mg/Nm^3 (expressed as NO_2 on a daily average basis). This range is valid for installations with and without co-incineration. SNCR is considered as Best Available Technique to achieve emission levels in this range. [BREF C+L 2000]

Industry has expressed a split view, as reported in the BREF, stating that the application of SNCR to reduce NOx levels to below 500 mg/m^3 was not widely enough experienced and uncertainty existed whether these NOx levels would lead to increased NH_3 emissions with SNCR. [BREF C+L 2000]

When SNCR is used and the molar ratio of ammonia injection is higher than 1.0-1.2, as well as if the temperature is below the optimum range, unconverted NH_3 may be emitted (“ammonia slip”). NH_3 also causes acidification and eutrophication and partly oxidises to NOx in the atmosphere causing similar impacts.

Injection of NH_3 may directly lead to increased NOx emissions if the temperature range for the NH_3 reaction is exceeded and injected NH_3 is oxidised to NOx inside the kiln.

The current BREF document contains the description of two Swedish cement plants (classified as existing plants according to WID), operating with SNCR since 1996/97 and both achieving NOx emission levels below 300 mg/m^3 at initial NOx levels of 1100 mg/m^3 and 750-1350 mg/m^3. Both plants use dry process technique. The kilns are equipped with cyclone preheater/precalciners. Only a small increase of NH_3 was found, no N_2O and no increase in CO emissions had been measured; no traces of any NH_3 had been found in the cement.

SNCR systems are applied where favourable reduction conditions in the cement burning process are found. This is the case if a temperature window of 850 – 1100°C exists providing sufficient retention time of the agents to react with NOx.

Normally 3-4 pair of nozzles is used for injection of ammonia water (25 %) or urea. Ammonia water has higher reaction efficiency in the temperature window. The increase of CO emissions is more prevalent with the use of urea.

As SNCR is best applicable to cement kilns where the required temperature window of 850 – 1100°C is accessible, the system is best to apply in cyclone preheater and in precalciner kilns but also in grate preheater (Lepol) kilns.

In long kilns (having capacities of > 3000 tons per day) it is more difficult to apply SNCR. Low reduction rates have been reported from kilns with production capacities of more than 4000 tonnes per day (see figure below). [Horton et al. 2006] In one long kiln, SNCR has achieved 40-50 % reduction efficiency, resulting in NOx emission levels below 900 mg/m^3. [CEMBUREAU 2006-1]

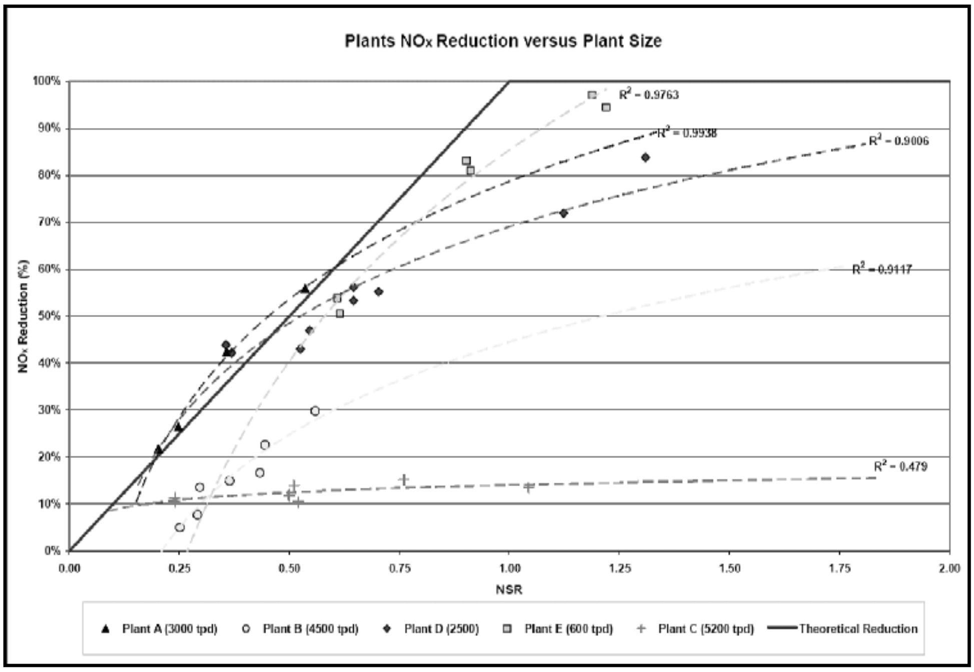

Figure 9: Results of NOx abatement with SNCR in cement kilns of medium and large size, related to NSR (normal stoichiometric ratio of reagent) [Horton et al. 2006]

In Germany long cyclone pre-heater kilns operating since early 90s with capacities of 5000 respectively 6000 tonnes per day have achieved stable NOx emission levels below 500 mg/m^3 with SNCR for several years. [Rüdersdorf 2000], [Rüdersdorf 2003], [Schwenk 2005/2006]

The adoption of a revised BREF document for the Cement and Lime Manufacturing Industries is scheduled for end of 2008. Background data for its elaboration has been delivered by the coordinating IPPC Bureau in Seville until May 2007.[162] According to these documents stable NOx emission levels of less than 500 mg/m^3 using SNCR are achieved by installations in Austria, Germany, Italy and Sweden; emission levels below 300 mg/m^3 are reported from Germany and Sweden.

Sweden has reported again on the two plants already mentioned in the current BREF document with three kilns operating at NOx levels around 200 mg/m^3 for many years now, being existing plants according to the WID. One of the plants has achieved yearly average NOx emissions of less than 260 mg/m^3 all years from 1999 to 2005, the other plant has achieved yearly average emissions of less than 180 mg/m^3 all years from 2000 to 2005. The reduction rate is about 80 % (from an initial NOx level of 800 - 1100 mg/m^3). Additional to natural ammonia slip of 10 - 30 mg/m^3 respectively 15 - 20 mg/m^3 in the other plant, SNCR related ammonia slip was observed with 5 - 10 mg/m^3 and 5 - 20 mg/m^3. [Junker/Lyberg 2007]

Austria will set NOx emission limits of 500 mg/Nm³ in 2007 for the daily limit value and also 500 mg/Nm^3 for the half hour limit value. In order to comply with these limit values, all 9 Austrian plants (being existing plants according to WID)

162 The first draft revised BREF document was published in September 2007, see http://eippcb.jrc.es/pages/FActivities.htm

will use SNCR. Until 2006, five plants had installed SNCR[163], reporting stable NOx emission levels below 500 mg/m^3. [Wietersdorf 2007]

The CEMBUREAU reports for BREF revision also mentions NOx levels below 500 mg/m^3 achieved with SNCR technique. The report states that in European countries about 100 SNCR installations are in operation. A figure presents emission levels of 50 installations with SNCR whereof 8 have a NOx emission level below 500 mg/m^3. [CEMBUREAU 2006-1]

In Germany since 1990 a daily limit value of at least 500 mg NOx/m^3 is required for existing and for new cement plants when co-incinerating waste. Several publications present examples of cement plants in Germany achieving NOx levels of less than 500 mg/m^3 being all classified as existing installations according to the Waste Incineration Directive [Bodendiek 2004], [CEMEX 2007], [Heidelberg 2006a- 2006e], [Holcim 2005], [Holcim/GTZ 2006], [Matthée 1999], [Rüdersdorf 2000], [Rüdersdorf 2003], [Schäfer/Hoenig 2006], [UBA 2007].

Overall in 2006, 47 out of 59 German kilns (82 %) achieved a NOx emission level of less than 500 mg/m^3. All but one kiln are existing installations. Among these kilns, one applies the semi-dry clinker process; all others use dry clinker process. The kilns are mainly equipped with cyclone pre-heaters, 7 of the kilns achieving NOx emission level of less than 500 mg/m^3 use grate preheaters. [UBA 2007] In 2006, 40 out of 59 kilns in Germany (68 %) had permits for waste co-incineration. 33 kilns of these kilns were already subject to the general requirement to observe the daily NOx limit value of 500 mg/m^3, while most of the other 7 kilns have to fulfil this requirement by the latest on 30 October 2007.

If more than 60 % waste is used for co-incineration, the German regulation generally requires application of the mixing rule setting the C_{proc} value with 500 mg/m^3 and the C_{waste} value with 200 mg/m^3. [17. BImSchV 1990], [17. BImSchV 2003] In 2006, 23 out of 59 kilns (39 %) had a permit for more than 60 % co-incineration, resulting in limit values between 200 and 333 mg/m^3. However, it was allowed to apply for a NOx ELV of 500 mg/m^3 on the basis of a derogation from the general requirement, valid latest until 30th October 2007. This derogation was used by all 23 kilns. [UBA 2007] Approaching the dead line of the derogation, several plants with high rates of waste co-incineration have achieved yearly average values around 300 mg/m^3 with SNCR [Rüdersdorf 2007, Märker 2007].

In order to investigate the possibility to lower the NOx emission limits after 30th October 2007 while using SNCR technique, tests were started in Germany in 2006/2007. For the test, a target value of 200 mg/m^3 NO_x was chosen for three months; for another 3 months period a target value of 350 mg/m^3 was fixed (daily mean values, standard dry conditions, 10 % O_2). The main findings of this test are summarized as follows:

[163] Lafarge Perlmooser AG in Retznei (since 2003) and in Mannersdorf (since 2005), Wopfinger Baustoffindustrie in Waldegg (since 2005) and Wietersdorfer & Peggauer Zementwerke in Peggau (since 2006). [Austria 2006]

- Based upon an initial NOx between 500 and 1400 mg/m^3 both target values could be met in the mill-on as well as in the mill-off operation mode[164].
- In case of the 350 mg/m^3 target value no significant increase in the average ammonia slip could be observed. Only a slight increase in the ammonia emissions of the kiln was measured in the mill-on operation mode. Only during mill-off operation a remarkable increase in the ammonia emissions could be observed.
- For the 200 mg/m^3 target value this increase in the ammonia slip was much higher for both operational conditions. In principle the measured ammonia slip was twice as high for the 200 mg/m^3 as for the 350 mg/m^3. The respective NH_3 emissions (not further detailed) in the mill-off operation mode were again much higher than in the mill-on operation mode.
  [Germany 2007], [BREF C+L 2007]

4.8.5. Technical feasibility of NOx emissions below 500 mg/m^3 using primary measures in combination with SNCR

The BREF document for the Cement and Lime manufacturing industries published in 2000 had evaluated the combination of staged combustion and SNCR as an emerging technique (not proven until 1999), arguing that “in theory, a combination of staged combustion and SNCR could be comparable to SCR in performance, that is NOx emission levels of 100-200 mg/m^3. [BREF C+L 2000] No difference is made between plants with or without co-incineration.

Long term tests by the German Research Institute of the Cement Industry (VDZ) have shown that the combination of staged combustion and SNCR could be determined as BAT for precalciner kilns. [Schäfer/Hoenig 2006]

It was proven that compliance with a NOx emission limit of 500 mg/m^3 can be achieved by using staged combustion in combination with SNCR, without occurrence of significant secondary emissions (NH_3 and CO). To obtain this, optimum position of injection lances has to be studied individually for each plant. Rapid and uniform intermixing of the reducing agent in the calciner is considered as essential for achieving effective NOx reduction of up to 70%.

It is stated that any further reduction of the NOx emissions can only be achieved with disproportionately high secondary emissions and costs. [Bodendiek 2004], [Schäfer/Hoenig 2006]

[164] Mill-on means that the emissions pass through the raw material in the raw mil, during mill-off mode they emit directly.

4.8.6. Technical feasibility of NOx emissions below 500 mg/m^3 using SCR

To avoid the need for waste gas re-heating, SCR in cement industry is not practiced after dust filters but before (“high dust SCR”). Pilot applications at low scale have been conducted in Kirchdorf/Austria (1996-2000) and in Solnhofen/Germany (1997 to 1999) as well as in Italy and Slite/Sweden, with a small portion of the exhaust gas (3%).

Based on these pilot applications, the Cement and Lime BREF included a view from a TWG member stating that selective catalytic reduction (SCR) is BAT with an associated NOx emission level of 100-200 mg/m^3. [BREF C+L 2000]

The pilot plant testing in Solnhofen was followed up in 2000 by a commercial high dust SCR installation, sponsored by the German Federal Environmental Agency. Solnhofen cement plant is a dry system preheater kiln without precalciner with a capacity of 1800 tonnes per day and regular NOx raw gas values of 1000-1600 mg/m^3.

The following findings about the Solnhofen plant have been reported [Haug et al. 2001], [Haug et al. 2002], [Germany 2006]:

- Consumption of NH_3 (25 % solution) was 46/64/85 litres/hour to achieve NOx final levels of 800/500/200 mg/m^3, with the initial NOx level being 1200 mg/m^3.
- Aiming at emission values below of 500 mg/m^3, NOx reduction rates of 60-70 % were achieved, resulting in emission values of 400-550 mg/m^3,
- When aiming at emission levels of 200 mg/m^3, emission levels of about 300 mg/m^3 were achieved;
- NOx reduction of 30 % was obtained without using ammonia, due to its presence in the raw material;
- NOx reduction of up to 80 % was achieved when irregular NOx raw gas values of 3000 mg/m^3 occurred;
- NH_3 slip was contained to less than 1 mg/m^3;
- No significant loss of activity with the first type of catalyst was observed after 40,000 hours of operation (4.5 years), whereas a second type of catalyst showed higher mechanical use and unexpected losses of activity;
- Reductions of VOC and SO_2 of about 50 to 70 % were attained.

At this plant, in 2004, 72.3 % of the NOx emission values achieved compliance with the NOx limit value of 500 mg/m^3; in 2005, 90.8 % compliance was achieved [Schreiber/ Russel 2006]. In 2006, an additional SNCR technique was installed at Solnhofen to be able to guarantee compliance with the emission limit value as at that time the most efficient first type of catalyst was not available on the market.

In 2006, a second large scale SCR application was installed in Italy, at Cementera di Monselice, which has a dry process cyclone preheater kiln with a capacity of 1800 tonnes per day. Initial NOx level is 1000-1100 mg/m^3. The SCR installation was designed for a capacity up to 2400 tonnes per day.

The SCR was designed for a NOx reduction of 90 % to a level of 230 mg/m^3. It is operated to achieve daily average NOx emission values below 500 mg/m^3. For testing and demonstrations, values below 100 mg/m^3 can usually be achieved. [Leibacher et al. 2006]

For economical reasons, most of the time the set point of the SCR is fixed at 400 mg/m^3. The system has been operating for 12 months without problems, achieving NOx emission values below 500 mg/m^3. Between February 2007 and July 2007 the value of 500 mg/m^3 was exceeded on 16 days (9 %). The legal emission limit value of 800 mg/m^3 was exceeded once (so < 1 %) by less than 10 %.[165]

Depending on the initial NOx level and the NH_3 injection, the NOx reduction efficiency ranges from 43 to 95 %. Daily average values in the order of 50 mg/m^3 have been achieved during the 6 weeks testing period. Corrections to 10 % O_2 result in lower concentrations equivalent to less than 68 g per tonne of clinker. [Leibacher et al. 2006]

Italy reported for the BREF revision about this plant, that during the first ten months of operation with SCR, the mean ammonia water consumption was 0.7-1.0 kg per tonne of clinker, with a NOx reduction from an initial level of 1000 mg/Nm^3 to less than 450 mg/Nm^3 (at 10 % O_2). [Italy 2007]

4.8.7. Summary on techniques to achieve NOx emission levels below 500 mg/m^3

Primary techniques can support achieving NOx emission levels below 500 mg/m^3. Staged combustion is the only primary technique that can be applied alone to achieve NOx emission levels below 500 mg/m^3. However, the use of staged combustion can not guarantee to safely comply with an emission limit value of 500 mg/m^3 because the process can not be sufficiently controlled.

The use of staged combustion in cyclone preheater kilns with tertiary air ducting and calciner does not achieve NOx emission levels below 500 mg/m^3, thus staged combustion is restricted to kilns with preheaters and precalciners.

165 For all daily emission values see: http://www.cementeriadimonselice.it/emissioni/emissioni.php

SNCR technique can achieve NOx emission levels below 500 mg/m^3. This is proven in Austria at least by five plants and in Sweden at least by two plants (the latter operating at levels of 250 mg/m^3 for about 10 years) and by more than 30 SNCR applications in Germany, a great part of which is operating successfully for several years with emission levels below 500 mg/m^3 complying with respective emission limit values. All plants except one of these German SNCR applications are existing plants according to the WID.

The plants operating SNCR techniques at NOx emission levels below 500 mg/m^3 comprise mainly dry processes but in Germany a SNCR system is successfully operated also for ten years in a semi-wet kiln classified as existing plant according to WID, complying with a NOx emission limit of 500 mg/m^3.

Most kilns using SNCR are equipped with precalciners, but SNCR is also successfully applied at kilns with grate preheaters (Lepol). Problems are reported to install SNCR successfully at long kilns (capacity > 4000 tonnes per day) as the optimum temperature window of 850-1100°C is difficult to achieve, but at least two existing plants in Germany with capacities of $\geq$ 5000 tonnes per day are operated for several years complying with a NOx emission limit of 500 mg/m^3.

SNCR technique can be combined with staged combustion and other primary techniques to achieve NOx emission levels below 500 mg/m^3 and to minimise the use of ammonia or urea. Large scale applications of SNCR and staged combustion have been conducted in Germany on plants defined as existing plants according to the Waste Incineration Directive, successfully achieving NOx emission levels below 500 mg/m^3.

SCR technique has been applied at large scale and as high dust SCR in two plants: in Solnhofen/ Germany for about five years and in Monselice/Italy for about one year, generally achieving successfully NOx emission values below 500 mg/m^3. Both kilns apply dry processes. They are existing plants according to the definition of the Waste Incineration Directive.

Mid-kiln firing can be applied in wet process kilns with efficiencies up to 60 %.

In general it can be concluded, that a high number of installations has shown that NOx emission levels below 500 mg/m^3 can technically be achieved with SNCR or SCR (supported by primary abatement techniques) in all dry and semi-wet process cement kilns if being "existing" plants according to WID.

Wet process kilns can only achieve the NOx emission level of below 500 mg/m^3 if the initial NOx raw gas level is about 1000 mg/m^3.[166]

166 Wet process kilns are reported to contribute with about 2.5 % to European cement production [BREF C+L 2007], without specification about their situation in EU 27 or other European countries (about 18,300 tons per day, about 8-9 kilns).

4.8.8. Costs for achieving NOx emissions below 500 mg/m^3

As only three abatement techniques are evaluated to achieve NOx emission values below 500 mg/m^3, only cost data for these techniques are presented.

Staged combustion: Cost calculations for staged combustion in combination with SNCR are not available. Investment into staged combustion depends on the design of the existing calciner. If no calciner exists, the investment of the calciner has to be added. Investment cost for installing staged combustion at a precalciners kiln is reported to be up to 2 million €, depending on the design of the existing calciners. [BREF C+L 2000]

Investment costs, sponsored by the German Federal Environmental Agency, for staged combustion at an existing plant in Germany (capacity 2000-2500 tonnes per day) have been reported with 3.32 million €, resulting in additional costs of 1.28 € per tonne of clinker. The investment aimed at achieving NOx emission levels below 800 mg/m^3 with an initial NOx level of ~ 1000 mg/m^3. [UBA 2005]

Investment costs to transform a preheater kiln with a grate cooler and a capacity of 3000 tonnes per day into a kiln with a precalciner and a duct is reported with 1 to 4 million €. [BREF C+L 2000]

Mid-kiln firing: Installation of a mid-kiln firing system in a wet process kiln have been reported with 3.2 m US-$ or about 2.5 m Euro in 2004. [ENVIRON 2004]

SNCR: Investment costs for SNCR consist of investment costs for storage, mixing devices, pumps, tubes and injection lances. Operating costs are mainly costs for ammonia water or urea, besides costs for electricity and maintenance.

It is reported that European authority's safety requirements for ammonia storage vary significantly, thus so do investment costs. The construction of the storage for the reducing agent amounts to about 50 % of the investment costs [Scur/Hoppe 2006].

Costs for ammonia water also vary and depend on transport distances. Sweden has reported that the price for ammonia water (25 %) has risen from about 100 to 130 €/t between 1996 and 2006. One of the Swedish plants using SNCR is situated on an island, thus ammonia costs generally include higher transport costs (about 140 €/t in 2006). [Junker/Lyberg 2006] Germany has calculated with ammonia water costs of about 90 €/t. [Germany 2006]

Costs for NOx abatement with SNCR technique are often published without details of the calculation. Basic data is mainly: investment data (depreciation period, interest rate), NOx reduction data (initial/final NOx level and/or NOx reduction in percent), ammonia data (ammonia costs, NH_3 consumption per tonne of clinker and/or per tonne of NOx reduced or applied molar ratio NH_3/NO), additional costs (electricity, maintenance, personal costs). This makes it difficult to compare the figures and to make general statements.

SCR: Investment costs for SCR consist of investment costs for the catalyst and cleaning devices. Operating costs are mainly costs for electricity, maintenance and change of the catalyst.

The two following tables show cost related data of SNCR and SCR technique, published in the last 10 years.

Table 92: Data related to NOx abatement with SNCR systems (marked in green: final levels are below 500 mg/m³)

Plant location (data reference year)	**Plant capacity**	**SNCR investment costs [million €]**	**SNCR operating costs [€ / tonne of clinker]**	**SNCR total costs [€ / tonne of clinker]**	**NOx initial level [mg/m³]**	**NOx level achieved [mg/m³]**	**NOx reduction efficiency**	**NH_3/NO molar ratio of the NOx abatement**	**Increase of NH_3 emission [mg/m³]**
N.N. Germany (2006)	3500 t/d	0.88 (4)	0.4 (4)		850 (4)	250 (4)	70 % (4)		
Sweden (1996) Slite	7000 t/d	1.1 (2)	0.55 (2)	< 0.6 (2)	1100 (2)	< 300 (3)	80-85% (2)	1.5-1.8 (2)	5-20 (2)
Sweden (1996) Skövte	1900 t/d	0.55 (2)	0.3 (2)		750 – 1350 (2)	< 300 (3)	80-85% (2)	1.2-1.4 (2)	5-10 (2)
Sweden (2006) Slite	7000 t/d	1.1 (2)	0.4-0.5 (3)	0.5–0.6 (3)	1100 (2)	< 300 (3)	80-85% (3)	1.5-1.8 (3)	5-20 (3)
Sweden (2006) Skövte	1900 t/d	0.55 (2)	0.35 (3)	0.4-0.45 (3)	750 – 1350 (2)	< 300 (3)	80-85% (3)	1.2-1.4 (3)	15 (3)
N.N. Austria (2004)	800 t/d	0.9 (7)	0.23-0.36 (7)	0.71-0.84 (7)	1150-1300 (7)	500 (7)	56-61% (7)		
N.N. Austria (2004	1200 t/d	1.22 (7)	0.22-0.35 (7)	0.64-0.77 (7)	1150-1300 (7)	500 (7)	56-61% (7)		
N.N. Austria (2004)	1800 t/d	1.62 (7)	0.21-0.34 (7)	0.58-0.72 (7)	1150-1300 (7)	500 (7)	56-61% (7)		
N.N. Germany (2006)	1500 t/d	0.6 (5)	0.3 (5)	0.38 (5)	1000 (5)	< 500 (5)	50 % (5)	(1.7x0.57=) 1.0 (5)	
N.N. Germany (2006)	1500 t/d	1.0 (5)	0.7 (5)	0.83 (5)	1000 (5)	< 200 (5)	80 % (5)	(2.5x0.57=) 1.4 (5)	
25 x Germany 1 x Austria (2005)		mean: 0.5-0.75 (4)		0.2 (4) 0.5-0.7 (4)	50 %: <1000 (4)	mainly: 400–500 (4)	low (4) medium to high (4)		
N.N.	3000 t/d	0.5-1.5 (2)	0.3-0.5 (2)		up to 2000 (2)	700 (2)	up to 65 % (2)		
N.N. Germany (2006)	1500 t/d			0.4-1.2 (4)					
Germany (1996)	840 t/d	1.18 (1)			2000 (8)	< 800	40-50%		
Germany (1996)	2000 t/d	1.02 (1)			1300-1500 (8)	< 800	40-50%		

(1) [UBA 2005]
(2) [BREF C+L 2000] based on [CEMBUREAU 1997] and [Junker]
(3) [Junker/ Lyberg 2006]
(4) [Scur/Hoppe 2006]
(5) [Germany 2006] based on German Environmental Protection Agency (UBA)
(6) [Haug et. al 2002]
(7) calculated on [Austrian EPA 2004], based on [Stubenvoll 2002], [Stubenvoll 1998]
(8) [Austrian EPA 1995]

Total cost evaluations for SNCR applications vary significantly according to the setting of depreciation periods, interest rates and ammonia costs. In general, no additional personnel costs are assumed for the total cost calculations.

The Austrian Federal Environmental Agency (UBA) has calculated with a depreciation of 15 years and 6 % interest rate. For maintenance and repair, 2 % of investment costs are assumed [Austria 2004]. The German Federal Environmental Agency (UBA) has calculated with a depreciation of 20 years, an inflation/hurdle rate of 3 % and costs for ammonia water (25 %) of 90 €/t [Germany 2006]. The German Cement Research Association has calculated with a depreciation period of 15 years [Scur/Hoppe 2006].

Table 93: Data related to NOx abatement with SCR systems (marked in green: final levels are below 500 mg/m³)

Plant location	Kiln capacity	SCR investment costs [million €]	SCR operating costs [€ / tonne of clinker]	SCR total costs [€ / tonne of clinker]	NOx initial level [mg/m³]	NOx level achieved [mg/m³]	NOx reduction efficiency	NH_3/NO molar ratio	Increase of NH_3 emission
N.N. Germany (2006)	1500 t/d	2.2 (1)	0.33 (1)	0.62 (1)	1000 (1)	< 500 (1)	> 50% (1)	0.8 (1)	none
N.N. Germany (2006)	1500 t/d	2.7 (1)	0.50 (1)	0.87 (1)	1000 (1)	< 200 (1)	> 80% (1)	1.0 (1)	none
N.N. Germany (2006)	1500 t/d	3.2 (2)	0.54 (2)	1.25 (2)	1200 (2)	< 800 (1)	80 % (2)	0.8 (1)	none
N.N. Germany (2006)	1500 t/d	4.2 (2)	0.94 (2)	2.00 (2)	1200 (2)	< 200 (1)	95 % (2)	0.8 (1)	none
Monselice Italy (2006)	1800 t/d (2400 t/d)*	4.5 (3) 3.6 (5)	NH_3: 30-300 l/h	1.0-1.3 (4)	1000-1100 (3)	< 450 (3)	43–97 % (4)	0.20-0.89 (4)	none

(1) [Germany 2006] based on German Environmental Protection Agency (UBA)
(2) [Germany 2006] based on [Scur/Hoppe 2006] for German Cement Works Association (VDZ)
(3) [Italy 2007], including 0.9 m Euro for catalyst [BREF C+L 2007]
(4) [Leibacher et al. 2006] * SCR is designed for a future capacity of 2,400 tonnes per day

Total cost evaluations for SCR vary significantly according to the setting of depreciation period, interest rates, ammonia cost and assumed catalyst life time.

German Federal Environment Agency (UBA) has calculated with a depreciation of 20 years, and an inflation/hurdle rate of 3% and a price for NH_3 (25 %) of 90 €. Catalyst life time was assumed with 40.000 hours (5.2 years of operation). Solnhofen plant operators have estimated a life time of the first catalyst type of 7-8 years [Germany 2006]. The German Cement Works Association (VDZ) has calculated with a depreciation period of 15 years and catalyst useful life of 4 years. [Scur/Hoppe 2006].

As a result of the calculations by the German Federal Environmental Agency, the operating costs for SNCR and SCR – including replacement costs for the catalyst – are roughly the same for a target NOx level of 500 mg/Nm³, while the total specific costs for SCR are approximately 60 % higher than for SNCR. For a target level of 200 mg/m³, total specific costs of SCR are about 5 % lower than for SNCR. [Germany 2006]

A SCR technique cost estimation of the German Cement Works Association (VDZ) additionally comprises costs for power consumption due to compressed air for the cleaning of the catalyst and the pressure drop due to the catalyst itself. The study resumes that total costs for SCR and SNCR only become similar if energy costs are low and ammonia prices high which is seen as little probabilistic because ammonia and energy costs tend to rise and fall simultaneously. If this is not the case, SNCR is considered to be more cost efficient. [CEMBUREAU 2006-1]

There is no consistency of cost data regarding the allocation of catalyst costs (may be included in investment of operational data).

4.8.9. Summary of costs for achieving NOx emissions below 500 mg/m³

In this chapter data are summarized on costs related with investment and operation of techniques to achieve NOx emissions below 500 mg/m³.

For primary techniques, the previous chapters have shown that it is difficult to generalise costs because the investment in these techniques depends to a large extent on the type of kiln (much more than for the investments needed for the secondary measures SNCR and SCR). In general it can be stated that investment in primary techniques for plants (if these imply the use waste) are often cost neutral or lead to cost savings due to waste reception revenues.

For mid-kiln firing, the investment (applicable for NOx reduction in wet kilns and long kilns) is estimated with 2.5 m Euro per kiln. With a depreciation of 20 years and capital costs of 10 %, annual costs are 215,000 Euro. This is equivalent to 0.14 Euro per tonne of clinker, assuming a kiln with a capacity of 5,000 tonnes, operating on 310 days per year with full capacity.

For secondary technique SNCR, the previous chapter has presented several cost data. The following figure shows all investment costs data of chapter 4.8.8 for SNCR in plants of different capacity.

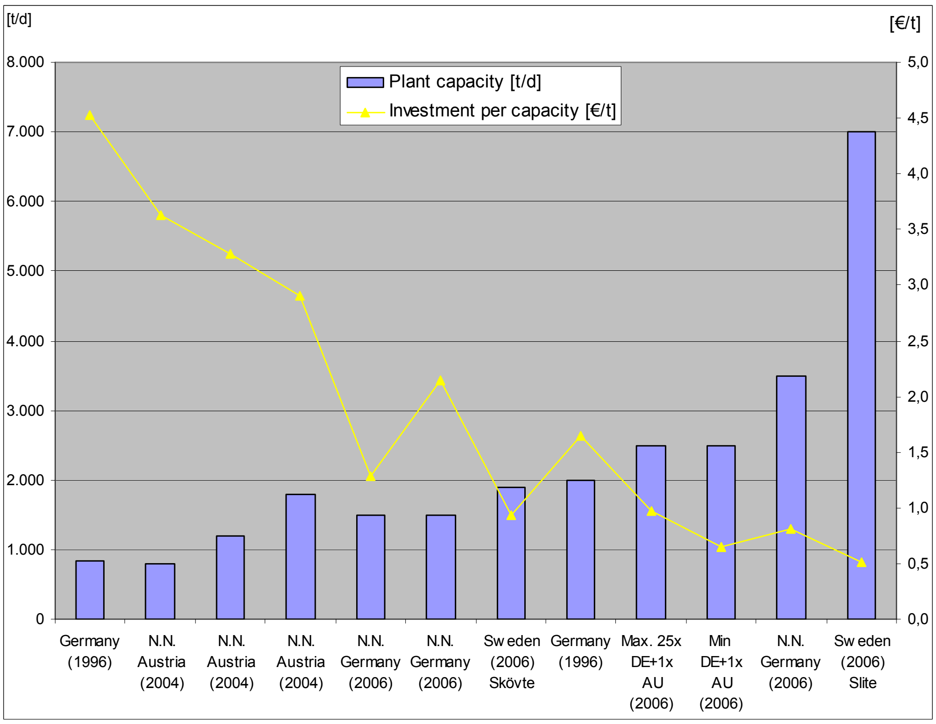

Figure 10: SNCR investment costs at different kiln capacities (Slite: 2 kilns), assuming production on 310 days per year with full capacity)

Austrian data from 2004 are remarkably higher than other data. They are based and extrapolated on a figure of 1998, adding a theoretical 40 % for control techniques. Compared to practical data, these figures are considered as too high.

Swedish data are practical data from two plants [Junker/Lyberg 2006]. German data are from two plants of 1996 [UBA 2005] and of an inquiry from 2005 [Scur/Hoppe 2006] comprising 25 German plants and 1 Austrian plant (presented above with its minimum and maximum values, setting the average plant capacity with 2500 t/d).

Mean investment costs for SNCR of 0.50-0.75 m Euro per kiln are assumed from average calculations on the sector (according to the mean of 26 plants).

Specific investment costs for SNCR range between 0.5-2.2 Euro per ton of clinker (assuming 310 days of production at full capacity, not taking into account the data of Austria). Mean investment costs for SNCR are therefore taken at **about 1.1 Euro per ton of clinker**.

From this, assuming a depreciation of 20 years and 10 % capital costs, SNCR investment is related with annual costs of about 0.11 Euro per tonne of clinker.

Operating costs for SNCR vary according to the NOx reduction efficiency. For plant operated to achieve the final NOx emission level of < 500 mg/m^3, as average, 0.3-0.4 Euro per tonne of clinker is resumed because most data are in this range.

Total costs of SNCR to achieve a final NOx emission level of < 500 mg/m^3 therefore result with **0.4-0.5 Euro per ton of clinker** (investment costs of 0.11 Euro per ton of clinker and operational cost of 0.3-0.4 Euro per ton of clinker).[167]

Assuming a cement price of 50-80 Euros per tonne in Europe,[168] total costs for SNCR to achieve a NOx level below 500 mg/m^3 are equivalent to 0.5 - 1.0 % of the cement price.

Investment costs for SCR depend more on the size of the plant than SNCR costs because the main cost driver is the catalyst and related housing. Cost data (see figure below) are derived from one large scale test application (incorporating additional operating options) and one SCR at a second plant (designed for an increasing plant capacity).

Investment costs for SCR to achieve NOx emissions below 500 mg/m^3 in a kiln with of 1,500 tonnes per day range from 2.2 m Euro (German Federal Protection Agency) to about 3.7 m Euro (German Cement Research Association) and 3.6 m Euro for a plant with a SCR designed for a capacity of 2,400 tonnes per day.

167 Compare Swedish plants [Junker/Lyberg 2006]: 0.4-0.6, German plants [Scur/Hoppe 2005]: 0.5-0.7 if medium to high NOx initial levels, 0.2 if low NOx emission levels are achieved without SNCR, German UBA calculation: 0.38.

168. Cement prices vary around 50-70 Euros per tonne in Central and Eastern Europe and about 70-80 Euros in UK and France. Prices are dominated by the clinker costs (clinker rate about 75-85 %), additive costs are 5-10 Euro per tonne.

Mean investment costs for SCR of 3.0-3.5 m Euro per kiln are assumed for average calculations.

Mean investment costs for SCR for average calculations on the sector result with **5.0 Euro per ton of clinker** to achieve a NOx emission level below 500 mg/m^3 (compare figure below).

Assuming a depreciation of 20 years and 10 % interest rate, SCR investment is related with mean capital costs of 0.50 Euro per tonne of clinker.

Operating costs for SCR vary according to the NOx reduction efficiency needed to achieve the final NOx emission level of < 500 mg/m^3. Reported data range between 0.3-0.7 Euro per tonne of clinker. A mean value of 0.50 Euro per tonne of clinker is assumed.

Total costs of SCR (investment and operation) to achieve a final NOx emission level of < 500 mg/m^3 result with about **1.0 Euro per ton of clinker**.

Assuming a cement price of 50-80 Euros per tonne in Europe, total costs for SCR to achieve a NOx level below 500 mg/m^3 are equivalent to 1.3 - 2.0 % of the cement price.

Additional specific costs for NOx reduction with SCR targeting at an emission level of 500 mg/m^3 are reported with 0.6-1.3 per tonne of clinker (0.71-1.12 € per tonne of cement), which is equivalent to 0.8-2.6 % of the cement price.

4.9. Analysis of impacts of reducing NOx emission limit values in existing cement plants

4.9.1. Problem definition

NOx emissions have direct and indirect impacts on health and environment. They build up secondary particulate matter, directly affecting health, e.g. by affecting the structure of lung tissue. NOx is a precursor of ground-level ozone. NOx emissions lead to acidification as well as to soil eutrophication. Air pollution with ozone and NOx produces long-range transboundary effects all over Europe and in European neighbour countries.

Cement installations co-incinerating waste are not only regulated by the Waste Incineration Directive but also by the IPPC Directive, provided that the installation has a production capacity exceeding 500 tonnes per day (whether or not co-incinerating waste). Due to economy of scale there are only few cement plants in the EU not subject to IPPC Directive. The IPPC Directive requires that permit conditions are based on the best available techniques (BAT).

The Reference Document on Best Available Techniques in the Cement and Lime Manufacturing Industries has defined NOx emissions of 200-500 mg/m^3 (expressed as NO_2 on a daily average basis) as BAT associated emission level.

In the BREF a split from industry is reported that the BAT associated NOx emission level is 500-800 mg/m^3. This view was referring to limited experience with the application of selective non-catalytic reduction (SNCR) at higher reduction efficiencies and the consequent uncertainty regarding additional ammonia emissions which may occur at high ammonia-water injection rates. [BREF C+L 2000]

There was another view in the TWG that selective catalytic reduction (SCR) is BAT with an associated NOx emission level of 100-200 mg/m^3, based upon SCR being regarded as an available and economically viable technique, drawing this conclusion from feasibility studies and successful pilot tests in the cement industry. [BREF C+L 2000]

Since 2005, the BREF for the cement and lime manufacturing industries is being revised; the first draft has been published in September 2007[169]; a final revised BREF document is expected to be adopted in 2009.

Cement kilns co-incinerating waste are falling under Directive 2000/76 on the incineration of waste (WID), which sets the minimum requirements for these plants, without prejudice to the requirements under the IPPC Directive.

169 http://eippcb.jrc.es/pages/FActivities.htm

Currently, Annex II.1.1 of the WID has an emission limit value of 500 mg/m^3 for new plants. For existing cement plants co-incinerating waste, the WID contains a daily emission limit value of 800 mg/m^3.

The following table shows the requirements of Directive 2000/76 for NOx emissions of cement plants co-incinerating waste:

Table 94: NOx emission limit values for cement plants (Annex II 1.1 of the Waste Incineration Directive)

Pollutant	C [mg/m^3] at 273 K, 101.3 kPa, 10 % O_2, dry gas
NOx for existing plants	800
NOx for new plants	500 (1)

(1) For the implementation of the NOx emission limit values, cement kilns which are in operation and have a permit in accordance with existing Community legislation and which start co-incinerating waste after the date mentioned in Article 20 (3) are not to be regarded as new plants.[170]

Until 1 January 2008, exemptions for NOx may be authorised by the competent authorities for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value for NOx of not more than 1200 mg/m^3.

The review clause in Article 14 of the Waste Incineration Directive asks the Commission to assess the economic and technical feasibility for existing cement kilns (as referred to in the footnote of the table in Annex II.1.1.), of respecting the NOx emission limit value for new cement kilns.

The study on technical feasibility and costs of the application of a limit value of 500 mg/m^3 in existing cement plants has shown that a NOx emission level below 500 mg/m^3 is technically feasible without significant increase of NH_3 emissions in all types of kilns, with restrictions for wet process kilns[171] having an initial NOx raw gas level higher than 1000 mg/m^3 (see chapter 4.8).

4.9.2. Objective of the proposed options

The background of the options proposed in this chapter is to assess the economic and technical feasibility for existing cement kilns co-incinerating waste of respecting the NOx emission limit value for new cement kilns (500 mg/Nm^3) as set out in Annex II.1.1 of the WID, according to the review clause in Article 14 of the WID.

The options are developed in the context of:

- The aim of the Waste Incineration Directive (Article 1) to prevent or limit emissions into air, as far as practicable.

[170] Article 20 ("Transitional provisions") of the Waste Incineration Directive:
(3) Stationary plant or mobile plants whose purpose is the generation of energy or production of material products and which are in operation and have a permit in accordance with existing Community legislation where required and which start coincinerating waste not later than 28 December 2004 are to be regarded as existing co-incineration plants.

[171] For new plants and major upgrades the best available technique for the production of cement clinker is considered to be a dry process kiln with muli-stage preheating and precalcination. [BREF C+L 2000]

- The NOx targets set by the Thematic Strategy on Air Pollution (NOx reduction by 60% until 2020, compared to the level of 2000). [COM Air 2005]
- The NOx targets of international protocols (Gothenburg Protocol of 1st December 1999 of the United Nations Economic Commission for Europe Convention on long-range transboundary air pollution to abate acidification, eutrophication and ground-level ozone [UNECE 1999]) and related Community regulations on National Emission Ceilings [Directive NEC 2001].

• Community legislation on NOx limit values in ambient air [Directive Air 1999] and the NOx guideline levels on health and vegetation protection, defined by the World Health Organisation ([WHO 2000], [WHO 2003]) .

4.9.3. Procedural aspects

As agreed with the Commission Services, the following assessment covers two options: “Business as usual” and “Amendment of the Waste Incineration Directive by setting a NOx emission limit value of 500 mg/m^3 for existing cement kilns co-incinerating waste”.

Data has been used from the feasibility study (chapter 4.8), as well as from literature study, from consultation of CEMBUREAU and individual plants.

4.9.4. Policy options

The option “Business as usual” is compared with the option to amend the Waste Incineration Directive by setting 500 mg/m^3 as NOx emission limit value for existing cement plants co-incinerating waste.

To achieve comparable scenarios, 2013 is set as the year for which the effect of both options is analysed, regarding this year as the first possible date of implementing amendments of the WID. Also for comparison reasons, the impact analysis for “Business as usual” will analyse the impacts on the same number of cement kilns which are assumed to be affected by implementation of option 2.

In option 2 the number of plants opting for co-incineration of waste until 2013 is the key assumption of the impact analysis.

To describe an unambiguous scenario for “Business as usual” based on the number of co-incinerating plants in 2013, the future level of NOx emissions of these plants has to be estimated as precise as possible.

However, the NOx emission level achieved in 2013 will depend on several key factors with uncertain impact for the affected installations (supposing that the general character of the IPPC Directive will not be changed):

- The consideration and application of the BAT reference document on Cement and Lime Manufacturing Industries (defining BAT associated emission levels) by competent authorities when revising or issuing permits for cement plants co-incinerating waste.
- The local necessity to reduce NOx emissions because of exceedance of NOx limit values in ambient air set by Directive 1999/30 [Directive Air 1999].
- The national necessity to reduce NOx emissions due to exceedance of the national emission ceiling set by Directive 2001/81 [Directive NEC 2001].
- Local public awareness to achieve high NOx emission reductions.
- The outcome of the revision of the BREF document on Cement and Lime Manufacturing Industries (future best available techniques and BAT associated emission levels), expected for end of 2008.

So far, the effect of the BAT associated emission levels mentioned for NOx in the Cement and Lime BREF has been limited. In particular, analysis by the Commission of the practice of IPPC Directive implementation has shown that the availability of a sector specific emission limit value (in the WID) setting minimum requirements is a strong incentive to effectively use this value as the "default" value for setting permit conditions.

The limited effect of the IPPC Directive implementation on NOx emissions in this sector is partly reflected by the NOx emission values of cement plants in 2004, as gathered by CEMBUREAU (including plants co-incinerating waste as well as plants without co-incineration). The inquiry reports yearly average NOx emissions from 258 kilns in Europe (see figure below). Four years after publication of the BREF document (defining a BAT associated emission level of 200-500 mg/m^3), 20 % of the kilns perform with yearly average emissions below 500 mg/Nm^3 (upper end of BAT associated emission level range, which is defined on a daily basis). The IPPC Directive has to be implemented in existing plants at the latest by 30th October 2007.

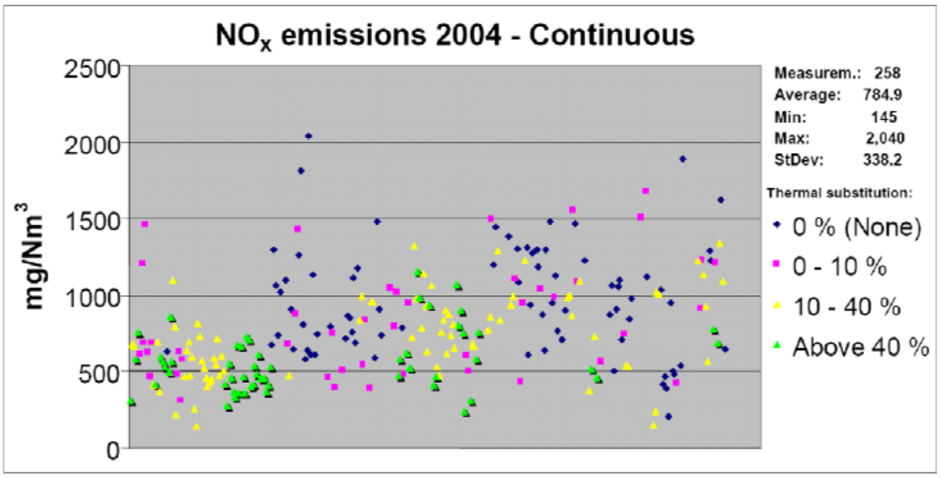

Figure 11: NOx emission from cement kilns in the EU-25 and EFTA countries in 2004 categorised by rate of substitution of fossil fuels by waste [CEMBUREAU 2006-2], [BREF C+L 2007]

Analysing the inquiry, it can be assumed that about 60 % of 56 kilns performing below 500 mg/m^3 had achieved this level due to requirements of a national regulations[172] (Germany); another 4 % had reached the level because of tax regulations (Sweden); several of the remaining ~20 plants had achieved the level due to special production processes (mainly white cement production, requiring lower temperature in the kiln).

Taking into account the potential drivers mentioned above, for the "business as usual" scenario it is assumed that in 2013 a majority of permits (70-90 %) for existing cement plants co-incinerating waste will contain NOx emission limits of 800 mg/m^3, which is required as minimum value by the WID.

Consequently, it is assumed for the "business as usual" scenario that a limited fraction (10-30 %) of permits for existing cement plants co-incinerating waste in 2013 will contain a NOx emission limit value of 500 mg/m^3 or less.

Existing cement kilns of Member States where setting a NOx emission limit value of 500 mg/m^3 (or lower) is already required when co-incinerating waste (AT, DE) or for tax regulations (SE) are considered separately.

Implementing emission limit values, the operational emissions will generally result in average emission levels about 10 % below the limit value itself because a security margin has to be preserved by the plant operators to avoid exceedance of emission limit values due to short time peak emissions. Therefore when setting a NOx emission limit of 500 mg/m^3 as daily limit value, it is assumed that an operational mean value of about 450 mg/m^3 will be achieved as yearly average value. Setting a NOx emission limit of 800 mg/m^3 as daily limit value, an operational mean value of about 750 mg/m^3 is presumed.

[172] A daily limit value of 500 mg/m^3 or less is required for cement plants co-incinerating waste in Germany.

Hence, the following options are analysed:

Option 1 (Business as usual): No amendment of the Waste Incineration Directive. The provisions of the IPPC Directive remain unchanged. The NOx emission limit value of 800 mg/m^3 applies for existing cement plants as a minimum requirement without prejudice to the requirements under the IPPC Directive. In 2013, 70-90 % of the existing cement kilns will achieve a NOx emission level of 750 mg/m^3, 10-30 % of the affected kilns achieve a NOx emission level of 450 mg/m^3. For comparison reasons, the analysed kilns in option 1 are the same as analysed in option 2.

Option 2: Amendment of the Waste Incineration Directive 2000/76: a NOx emission limit value of 500 mg/m^3 is set for existing cement plants co-incinerating waste, without prejudice to the requirements under the IPPC Directive. The provisions of the IPPC Directive remain unchanged.

4.9.5. Identification of priority impact categories

The identification of impact categories and the screening of impacts relevant to each stakeholder group (business, consumers, public authorities and the environment) came to the following result:

1) Economic impacts: Most relevant impact categories may be competitiveness, competition in the internal market, trade and investment flows, operating costs, administrative costs, and macroeconomic environment. Possible relevance is seen for the impact category consumers and households, innovation and research, specific regions and public authorities. No relevance is seen for the categories conduct of business, property rights, third countries and international relations.

2) Environmental impacts: Most relevant impact categories may be air and water quality, environmental risks, soil quality, animal health, food and feed safety, biodiversity, flora and fauna, waste production, use of energy. Possible relevance is seen for the categories climate, respectively non-renewable resources and waste recovery. No relevance is seen for the categories renewable resources, landscapes, land use, mobility (transport modes).

3) Social impacts: Most relevant impact categories may be public health and safety, workers' health, good administration, employment and labour markets. Categories with low priority are standards and rights related to job quality, social inclusion and protection of particular groups, equality of treatment and opportunities, non-discrimination, private and family life, personal data, governance, participation, access to justice, media and ethics, crime, terrorism and security, access to and effects on social protection, health and educational systems.

4.9.6. Affected stakeholder groups

4.9.6.1. Cement industry

In principle, all cement plants are affected by option 1 (business as usual); but for the purpose of comparison with option 2, only plants being affected by option 2 will be considered under “Business as usual”.

Option 2 affects all cement plants that co-incinerate waste and that are classified as “existing installation” according to the definition of the Waste Incineration Directive (Article 3 No. 6).173 Option 2 (as option 1) has an effect only on those plants currently not achieving a daily NOx emission limit level of less than 500 mg/m3.

In the following paragraphs calculations are made to estimate the total number of existing cement kilns co-incinerating waste in 2013 and also the number of kilns currently already achieving a NOx emission level of less than 500 mg/m3.

CEMBUREAU has reported for 2006 a total number of 268 cement plants with 377 cement clinker kilns for EU 27, being not all in operation [BREF C+L 2007]. Hence, it is assumed that in 2007 and in 2013 about 260 cement plants and 360 clinker kilns are in operation in EU 27.

Regarding the status of co-incineration, CEMBUREAU has reported from its members in 23 European countries174 162 plants practicing co-incineration in 2005 [CEMBUREAU 2007]. This represents about 55 % of the total number of 260 plants. An inquiry on emission data and waste co-incineration of 258 kilns shows that 70 % of the kilns practice waste co-incineration in 2004 [CEMBUREAU 2006-2].175 It is assumed that about 252 kilns are in operation and co-incinerate waste at present (70 %, classified as existing or as new plants).

The evaluation of NOx emission levels in 2004 shows that NOx emission levels below 500 mg/m3 are already achieved by 30 % of (new or existing) plants practicing co-incineration of waste (see figure below) [CEMBUREAU 2006-2].

Based on this share it is assumed that 30 % of 252 kilns co-incinerating waste already achieve NOx emission levels of about 450 mg/m3, (about 76 kilns, classified as “new” or as “existing”).

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173 Existing plant is defined as a plant which is in operation and has a permit in accordance with existing Community legislation before 28 December 2002, or, which is authorised or registered for incineration or co-incineration and has a permit issued before 28 December 2002 in accordance with existing Community legislation, provided that the plant is put into operation not later than 28 December 2003, or which, in the view of the competent authority, is the subject of a full request for a permit, before 28 December 2002, provided that the plant is put into operation not later than 28 December 2004;

174 Data comprising Norway and 22 EU Member States, without data of Cyprus, Bulgaria, Lithuania and Slovakia (no cement plant in Malta)

175 In 2004, about 17 % of the energy supply of the European cement industry was provided by waste used as fuel. [CEMBUREAU 2006-5]

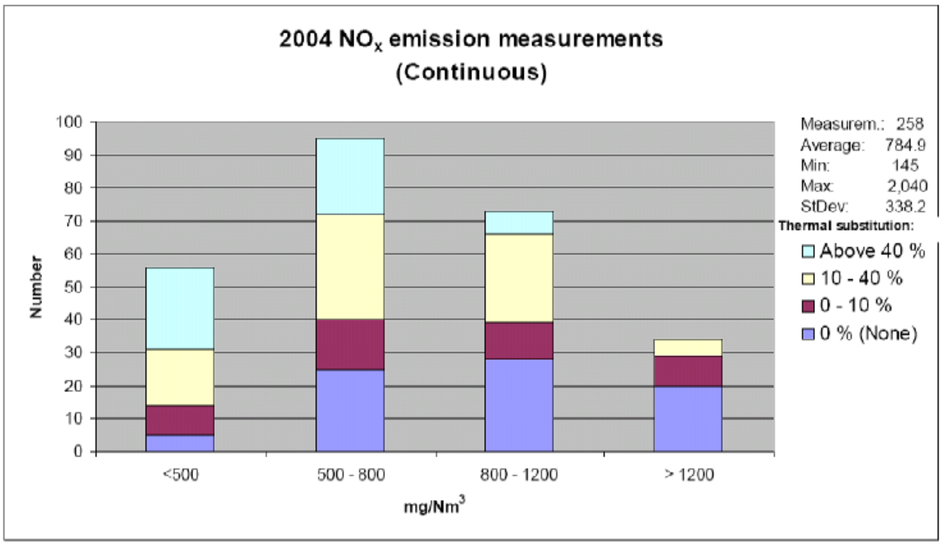

Figure 12: Distribution of yearly average NOx emission values categorised in thermal substitution rates from continuous measurement in 258 cement kilns in 25 European countries (including CH, NO, TR) in 2004 [CEMBUREAU 2006-2]

The figure of 76 kilns currently achieving NOx emission levels below 500 mg/m3 is consolidated by the fact that at least 53 kilns (existing or new) co-incinerate waste and achieve NOx emission levels below 500 mg/m3 latest by November 2007 due to national emission limit values (~40 kilns in Germany, 10 kilns in Austria) or due to tax regulations (3 kilns in Sweden), independently from implementing option 2 (see also table below with national limit values). [UBA 2007], [Austria 2006], [Junkers/Lyberg 2006] 176

Some other kilns (new or existing) already co-incinerate waste and achieve NOx emission levels below 500 mg/m3 (e.g. Rochefort-sur-Nenon/France).[177]

For comparison reason, analysis of option 1 will include only cement plants classified as "existing" because only existing plants are included in the analysis of option 2.

Out of 162 plants reporting co-incineration of waste, 145 plants (90 %) have been classified as existing plants, 17 (10 %) as new plants [CEMBUREAU 2007]. As tendentially new plants are rather CEMBUREAU members than old plants, the total share of new plants in EU 27 is assumed as smaller. It is estimated that in EU 27 currently and in 2013 not more than 20 plants with 25 kilns (7 %) are in operation and classified as "new kilns" according to the WID definition.

[176] In a rough assumption it is presumed that kilns achieving an annual NOx average value below 500 mg/m³ also comply with a NOx emission limit value of 500 mg/m³.

[177] see http://www.holcim.com/gc/FRBE/uploads/FRBE_SD_BILAN2005_ROCHEFORT.pdf

Consequently, about 240 plants with 335 kilns are classified as "existing".

Of these 335 existing kilns only those kilns are considered as affected by option 1 and option 2 that will co-incinerate waste in 2013.

It is assumed that in 2013 only 5 % of all existing kilns (17 kilns) will not use waste due to specific products (like white cement), due to difficulties of economic waste feeding, because of difficulties with chlorine enrichment (and high costs of relieving by-pass construction) or due to image reasons or public opposition to waste co-incineration. All other 318 existing cement kilns are supposed to start or to continue waste co-incineration for economic reasons (increasing energy costs) in the next 5 years until 2013.

On this basis it is estimated that in EU 27 in 2013 about 318 existing cement clinker kilns will be falling under the WID (95 %). Another 17 existing kilns will not fall under the WID (5 %) and will therefore not be included in the analysis of options.

For the 318 kilns, both options will have no effect on those kilns that currently co-incinerate waste and already achieve NOx emission levels below 500 mg/m3. Based on about 76 kilns co-incinerating waste and already achieving this level, considering the above mentioned share of 90 % existing kilns**, 68 kilns are supposed to co-incinerate waste as existing kilns and already achieving NOx emission levels below 500 mg/m^3.**

Consequently, another 8 kilns (10 %) are supposed to co-incinerate waste as new kilns, performing with a NOx emission level below 500 mg/m^3.

Therefore, option 1 and 2 will affect 318 existing kilns co-incinerating waste. The options will have no effect on 68 of the kilns but only on 250 existing kilns supposed to co-incinerate waste in 2013 and at present not achieving an emission level below 500 mg/m^3.

The following table illustrates the current NOx emission limit values set in EU 27 for new and existing cement clinker kilns co-incinerating waste.

Table 95: National NOx emission limits for the production of clinker in Europe in installations covered by the Waste Incineration Directive

Country	NOx [mg/m³] Existing plants	NOx [mg/m³] New plants	Comment
Austria	800 a)	500	
Belgium	800	500	
Bulgaria			CEMBUREAU member after 1/7/2007
Cyprus			no CEMBUREAU member
Czech Republic	800 b)	500	Limits for co-incineration < 40% hazardous waste
Denmark	1200	800	
Estonia	800		
Finland	1200/800		Existing old permits/ New permits
France	800 b)	500	Additional regulatory limits on waste
Germany	500 d)*	500 d)	
Greece	800	500	Higher limits can be accepted until 1/1/08 for NOx (max=1200) for kilns burning < 3 t/h of waste.
Hungary	800	500	
Ireland			WID will apply
Italy	800	500	Decree's draft
Latvia		500	
Lithuania			no CEMBUREAU member
Luxemburg	800	500	
Malta			no CEMBUREAU member
Netherlands	800	500	
Norway	800		
Poland	800	500 e)	
Portugal	800		
Romania	800	500	Exemption can be accepted until 1/1/08 for NOx (max=1200) for kilns burning < 3 t/h of waste.
Slovenia	800		
Slovakia			no CEMBUREAU member
Spain	800 b)	500	
Sweden	800 c)	500	
Switzerland	800		
Turkey	1500; 1300; 1800		no details specified
United Kingdom	800	500	

a) 800 mg/Nm³ for existing plants only until 31.10.2007, afterwards 500 mg/Nm³
b) Exception to 1200 mg/m³ until 1/1/2008 when the waste output is lower than 3 t/h or with wet kiln
c) It is possible for existing plants to have an exemption for the emissions of NOx (1200 mg/Nm³) until 2007-12-31.
d) If the substitution rate via waste is > 60 % the emission limit declines according to the mixing rule (200 - 500 mg/m³), *latest by 30 October 2007
e) 800 mg/Nm³ for kilns which started combusting wastes before 28 December 2004

[CEMBUREAU 2006-4], * additional information by Ökopol

4.9.6.2. *Cement industry suppliers*

- Suppliers and maintainers of NOx abatement technology are affected (injection nozzles, pipes, pumps, tanks, catalysts, SCR construction).
- Suppliers of ammonia water and urea are affected.

4.9.6.3. *Consumers and households*

⇨ Consumers and households are only affected if they plan to invest in private housing.

4.9.6.4. Public authorities

- Public authorities are concerned as far as they are involved in permitting procedures of NOx abatement and in performance control by monitoring (evaluation of reports).

4.9.6.5. Environment

⇨ Air, water, soil and wildlife, flora and fauna are concerned.

4.9.7. Analysis of impacts – Option 1: Business as usual

4.9.7.1. Possible development in the context of option 1

Existing cement kilns co-incinerating waste are subject to the minimum emission limit value of 800 mg/Nm^3, defined in the WID. The possible derogation setting an emission limit value up to 1200 mg/m^3 in Annex II.1 of the WID will stop applying after 1st January 2008. Hereafter, all existing cement kilns co-incinerating waste shall comply at least with a NOx emission limit value of 800 mg/Nm^3.

The permit conditions of cement kilns (whether or not co-incinerating waste) which are subject to the IPPC Directive shall be based on the application of BAT definitions published in BREF documents, taking into account local conditions. The deadline for compliance with the requirements of the IPPC Directive for existing plants is 30th October 2007.

The current BREF document for the Cement and Lime Manufacturing Industries (published in 2000) has defined NOx emission values between 200 and 500 mg/m^3 as BAT associated emission level for new and existing cement plants (with or without co-incinerating of waste).

Because of the minimum requirements for emissions is set by a sectoral Directive, it is assumed that permits will mainly include the corresponding WID emission limit value (compare drivers and uncertainties described in chapter 4.9.4).

Therefore in 2013 under option 1 existing cement kilns co-incinerating waste and not yet performing with a NOx emission limit value below 500 mg/m^3 (i.e. kilns in AT, DE, SE) will mainly (70-90 %) have to comply with the minimum daily NOx emission limit value of 800 mg/m^3 and to a limited extent (10-30 %) will have to comply with a daily NOx emission limit value of about 500 mg/m^3.

Table 96: Effects of option 1 on existing cement kilns co-incinerating waste in 2013

Option 1	Total	Kilns having a NOx level < 500mg/m^3	Kilns with current NOx level of > 500mg/m^3	70-90 % of kilns with future NOx limit of 800 mg/m^3	30-10 % of kilns with future NOx level of $\leq$ 500 mg/m^3
Share of total	100 %	21 %	79 %	55-71 %	24-8 %
Number of kilns	318	68	250	175-225	75-25
Effect of option 1	partly	no	yes	yes	yes

4.9.7.2. Economic effects of option 1

Above it was estimated that about 318 existing cement kilns will co-incinerate waste in 2013 whereof 250 kilns will not be subject to an emission limit value of 500 mg/m^3 or less.

For option 1 it is supposed that 10-30 % of these kilns (mainly AT, DE and SE) will have permits in 2013 requiring a NOx limit value of 500 mg/m^3 or less. 70-90 % will have permits containing emission limits of 800 mg/m^3. To comply with these permits, both groups have to implement effective abatement techniques.

To quantify the economic effects of option 1, the cost data of chapter 4.8.9 on technical feasibility and costs of implementing a NOx emission limit of 500 mg/m^3 will be used.

It has been reported that many kilns are able to achieve a NOx initial level of about 1,000 mg/m^3 only by applying primary measures [Scur/Hoppe 2006]. The techniques that will be used with highest probability for achieving further NOx reduction to levels below 800 or below 500 mg/m^3 is supposed to be SNCR, due to lowest investment costs and generally (for the levels aimed at) also lowest total costs (compare chapter 4.8.9).

For achieving an emission level below 500 mg/m^3, total costs have been evaluated with a mean of 0.4-0.5 € per tonne of clinker for installing SNCR technique (depreciation period of 20 years and capital costs of 10 %). Based on a price range of 50-80 € per tonne of cement in EU 27,[178] SNCR costs to achieve an emission level of 450 mg/m^3 will cause an increase of about 0.5-1.0 % of the cement price.

In chapter 4.8.9, operational costs to achieve a NOx level below 500 mg/m^3 with SNCR are estimated with 0.3-0.4 Euro per tonne of clinker. For the purpose of estimating costs to achieve a NOx level of 750 mg/m^3 with SNCR, it is assumed that about 50 % of the operational costs arise[179], thus about 0.15-0.2 Euro per tonne. Investment costs are supposed to be similar (~0.1 Euro per tonne of clinker), resulting in total costs for SNCR of 0.25-0.3 Euro per tonne of clinker.

Based on a price range of 50-80 € per tonne of cement, SNCR to achieve an emission level below 800 mg/m^3 will cause an increase of about 0.3-0.6 % of the cement price.

Increase of cement prices due to one of the two possible implementations of option 1 is not considered as a relevant increase regarding international competition with EU-foreign countries.

[178] Taking into account a clinker rate of 75 – 85 % and additive costs of 5-10 Euro per tonne.

[179] Based on Scur/Hoppe [2005], reporting that in many kilns a NOx level of 1,000 mg/m^3 was achieved without secondary techniques, and a linear NOx reduction, thus about 50 % to achieve 500 mg/m^3, about 25 % to achieve 750 mg/m^3.

The implementation of option 1 (business as usual) may have a negative effect on investment cycles due to binding of a relevant capital of about 500-750,000 Euros per kiln. If this investment is realised in about 250 kilns until 2013 to achieve NOx emission levels of less than 800 mg/m^3 respectively less than 500 mg/m^3, a **total investment of about 125-188 m Euro is realised in EU 27**.

To obtain the additional annual costs related to the implementation of option 1, the annual costs per kiln have to be calculated.

The affected 250 kilns comprise about 70 % of the total number of 360 kilns operating in EU 27 in 2007. In a rough estimation it is assumed that the affected plants produce 70 % of the total production of about 267.5 m tonnes cement (reported for EU 27 in 2006 [BREF C+L 2007]) equivalent with about 187 m tonnes of cement and 150 m tonnes of clinker (assuming a clinker rate of 80 %). The total amount results in an average clinker production per kiln of about 600,000 tonnes per year, resulting in an average production of about 2,000 tonnes of clinker per day produced on 300 days.

Based on specific cost data and average data on clinker production per kiln, the total annual costs for implementing option 1 are estimated with **40-48 m Euro** if 10 % of the affected kilns will have to achieve BAT associated emission levels below 500 mg/m^3 (the remaining share of kilns has to comply with an emission limit value of 800 mg/m^3). Total annual costs sum up with **44-54 m Euro** if 30 % of the kilns have to achieve BAT associated emission levels and remaining kilns comply with 800 mg/m^3.

Option 1 (business as usual) can have significant negative effects on competition in the internal market, because no level playing field for cement industry co-incinerating waste in EU 27 is expected in the medium term, due to the fact that at least 68 kilns will have to comply with NOx emission limits of at least 500 mg/m^3 due to national regulations in Austria, Germany and Sweden, and additionally between 25 and 75 kilns (10-30 % of 250 kilns) will have to achieve emission levels below 500 mg/m^3 whereas between 175-225 kilns (70-90 % of 250 kilns) will have to comply with a limit value of 800 mg/m^3.

Three Swedish kilns already perform with NOx emission level of about 200 mg/m^3. In Germany, after 30 October 2007, national regulations require a NOx emission limit in the range from 500 to 200 mg/m^3 if corresponding with a waste input of 0 to 100 % for co-incineration; in 2006, more than 20 kilns provided of a permit for at least 60 % co-incineration with a corresponding NOx emission limit value of at least 330 mg/m^3. Therefore it is assumed, that the 68 kilns already providing of a NOx emission limit value of 500 mg/m^3 or less will have a NOx emission level of about 350 mg/m^3 in 2013.

Increasing operational costs may lead to increase of imports from Eastern Europe affecting local market conditions in specific regions (EU 27 frontier countries). Therefore negative effects will be mainly restricted to countries like Finland, Poland, Romania and Bulgaria. **It is assumed that about 10 existing cement kilns of the total of about 335 existing kilns would be affected (< 3 %).**

A limited positive effect is expected for the private market of suppliers of waste gas abatement techniques due to broader markets (providers mainly originate from Austria, Germany, Switzerland and UK). This can result in positive effects for research & development and innovation of environmental protection techniques.

No relevant effect on consumers and households is expected because cement costs increase about 0.3-0.6 % and in some areas (near kilns having to achieve BAT associated emission levels) between 0.5-1.0 % per tonne of cement. The effect may be of relevance e.g. for those consumers having the intention of investing in private housing.

The implementation of option 1 (business as usual) may have a relatively negative effect on some small installations (around 500 tonnes per day) compared with big plants, especially because investment costs do not increase linearly. No detailed data on the number of smaller plants is available. However, the number of affected small installations is estimated with max. 5 kilns.

Negative effects on smaller installations may lead to loss of jobs if these installations are not able to compete, due to higher production costs, arising from elevated expenses for NOx abatement.

Option 1 (business as usual) may have a negative effect on the macroeconomic environment due to the maintenance of non-level playing field, although this effect is limited by the fact that in general cement transport does not exceed 200 km distance.

No effect is expected for European trade policy with third countries.

The implementation of option 1 (business as usual) will maintain the non-level playing field between the sector of waste incineration (existing incineration plants having been obligated to reduce NOx levels below 200 mg/m^3 since the end of 2005) and the cement industry when co-incinerating waste.

4.9.7.3. Environmental effects of option 1

The environmental benefit of option 1 depends upon the NOx emission reductions achieved until 2013.

To quantify the environmental effect, the NOx emission reduction of option 1 is estimated by the future average NOx emission levels and related to the current emission level. For 2004, the mean of annual average values of NOx emissions from 258 kilns was reported with 785 mg/m^3. [CEMBUREAU 2006-2], [BREF C+L 2007]

It is supposed that the implementation of option 1 will lead to a mean NOx emission level of 450 mg/m^3 for a small share of kilns where BAT associated emission levels are implemented, and to a mean value of about 750 mg/m^3 in those plants having to comply with a NOx emission limit value of 800 mg/m^3.

Existing kilns assumed to co-incinerate waste in 2013 and not performing with BAT associated emission levels in 2007 are supposed to amount with 250 kilns.

If in 2013 a share of 10 % of the permits will set emission limits that lead to BAT associated emission levels, and the remaining 90 % will have to comply with an emission limit value of 800 mg/m^3. In this case, the following emission levels and numbers of kilns are expected (see also table below):

- 350 mg/m^3 in 68 kilns, subject to emission limits of 500 mg/m^3 or less,
- 450 mg/m^3 in 75 kilns subject to an emission limit of 500 mg/m^3,
- 750 mg/m^3 in 175 kilns subject to an emission limit of 800 mg/m^3,
- resulting in an expected average emission level of 641 mg/m^3.

Table 97: Effects of option 2 on existing cement kilns co-incinerating waste in 2013

Option 1	**Total**	**Kilns having a NOx level < 500mg/m³**	**Kilns with current NOx level of > 500mg/m³**	**90 % of kilns with future NOx limit of 800 mg/m³**	**10 % of kilns with future NOx level of ≤ 500 mg/m³**
Share of total	100 %	21 %	79 %	71 %	8 %
Number of kilns	318	68	250	225	25
2004 emission level	~785	~350	~903	~903	~903
2013 emission level	~641	~350	~720	750	450

In a rough estimation it is assumed that the NOx reduction is linear to the reduction of the yearly average NOx emission level. Under this condition, the calculation stated above will result in a reduction of 144 mg/m^3 between the average NOx emission levels in 2004 of 785 mg/m^3 and the expected average NOx emission level in 2013 of 641 mg/m^3, equivalent to a NOx emission reduction of **18.3 %.**

The European Pollutant Emission Register (EPER) includes under NACE code 26.51 NOx data of 230 cement plants in EU 25 (compared to a total of about 255 plants in EU 25 in 2005, some not in operation, some not exceeding 500 tonnes capacity per day [CEMBUREAU 2006-3]).

NOx emissions for 2004 of these plants sum up to 345,845 tonnes [EPER 2004].

Most cement plants report to EPER, as for reasons of economy of scale only very few of the plants in EU 27 have a capacity of ≤ 500 tonnes per day.

Regarding the fact that plants of Bulgaria and Rumania are missing in EPER 2004, and some large plants have not reported to EPER under NACE code 26.51 (e.g. choosing code 26.50, see [UBA 2007]), it is assumed that total NOx emissions of cement industry was about 360,000 tonnes in 2004. A reduction of 18.3 % is equivalent with **65,900 tonnes** of annual NOx reduction from 2013 on by this alternative of option 1.

If in 2013 a share of 30 % of the permits will include emission limits that lead to BAT associated emission levels, and the remaining 70 % have to comply with an emission limit value of 800 mg/m^3, the following emission levels and numbers of kilns are expected (see also table below):

- 350 mg/m^3 in 68 kilns, subject to emission limits of 500 mg/m^3 or less,
- 450 mg/m^3 in 25 kilns subject to an emission limit of 500 mg/m^3,
- 750 mg/m^3 in 225 kilns subject to emission limit of 800 mg/m^3 by option 1,
- resulting in a supposed average emission level of 594 mg/m^3.

Table 98: Effect of option 1 related to average annual emission levels with 30 % BAT level implementation

Option 1	**Total**	**Kilns having a NOx level < 500mg/m^3**	**Kilns with current NOx level of > 500mg/m^3**	**70 % of kilns with future NOx limit of 800 mg/m^3**	**30 % of kilns with future NOx limit of ≤ 500 mg/m^3**
Share of total	100 %	21 %	79 %	55 %	24 %
Number of kilns	318	68	250	175	75
2004 emission level	~785	~350	~903	~903	~903
2013 emission level	~594	~350	~660	~750	~450

In a rough estimation it is assumed again that the NOx reduction is linear to the reduction of the yearly average NOx emission level. Under this condition, the calculation above results in a reduction of 191 mg/m^3 between the average NOx emission level in 2004 and the expected average NOx emission level in 2013. This is a NOx emission reduction of **24.3 %**.

Assuming NOx emission of cement industry was about 360,000 tonnes in 2004, a reduction of 24.3 % is equivalent with **87,500 tonnes** of annual NOx reduction from 2013 on by this alternative of option 1.

The annual environmental benefit by NOx reduction depends significantly on the ambient air quality level around the installation and can only be estimated by rough assumptions.

The environmental benefit by implementing option 1 (business as usual) will result in positive effects on air quality, which in its turn has positive effects on water quality, reduces environmental risks, improves animal health, biodiversity, as well as flora and fauna. On soil, the implementation of the option has a positive effect because less acidification results.

The software tool "EcoSense" [EcoSense 2004] has been developed in the context of the European project "Clean Air for Europe" (CAFE) for the analysis of environmental and health effects.[180] The internet based tool enables to analyse the effects of a NOx reduction realised in EU 27 by allocating the reduction to all countries.

According to EcoSense, calculating with the value of life year lost concept (VOLY), using a median value of 52,000 Euro and a mean value of 120,000 Euro (according to the Clean Air for Europe project [CAFE 2005]), an annual NOx emission reduction of 65,900 tonnes (**option 1a**, with 10 % of permit emission limit values at 500 mg/m^3) would result in **annual environmental and health benefits of 167-281 m Euro.**

Implementation of **option 1b** with an annual NOx emission reduction of 87,500 tonnes (with 30 % of permit emission limit values at 500 mg/m^3) would result in **annual environmental and health benefits of 221-373 m Euro**.

Cross-media effects may result from implementing option 1 because NOx reduction will mainly be obtained by ammonia injection (SNCR). The use of ammonia for SNCR leads to cross-media effects due to the use of energy for ammonia production, delivery, mixing, transport and injection. This leads to the additional use of non-renewable resources for energy production with negative effects on climate.

Cross-media effects are also expected if ammonia emissions rise due to non-optimised ammonia injection for NOx abatement by SNCR.

4.9.7.4. Social effects of option 1

Option 1 (business as usual) has a positive effects on human health (see above under environmental effects).

Implementing option 1 (business as usual) does not create public confidence in a high level of environmental protection by waste incineration because of inconsistency between IPPC requirements to considerate BAT associated emission levels and WID requirements leading to emission levels of at least 60 % (up to 400 %) higher than the emission levels associated with BAT since 2000.

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[180] See http://externe.jrc.es/Method+EcoSense.htm and http://ecoweb.ier.uni-stuttgart.de/ecosense_web/ecosensele_web/frame.php

Considering impacts on worker's health by implementing option 1, negative effects are possible, as SNCR technique is mainly operated with ammonia (urea is used but less effective). Cement plant operators may be exposed to risks when handling ammonia during loading and maintaining.

4.9.8. Analysis of impacts – Option 2: Implementation of a NOx emission limit value of 500 mg/m^3 under WID for existing cement plants co-incinerating waste

4.9.8.1. Possible development in the context of option 2

It is assumed for this option that the new emission limit value of 500 mg/m³ of the amendment Waste Incineration Directive will come into force for existing cement plants by 1st January 2013.

In chapter 4.9.6 it was estimated that a total of 318 existing cement kilns will fall under the WID in 2013. On 68 kilns of these kilns, option 2 has no effect because they already comply with NOx emission limits of 500 mg/m3 or stricter.

Therefore the effect of the implementation of option 2 is restricted to the remaining 250 existing cement kilns supposed to co-incinerate waste in 2013 and to perform currently with a daily NOx emission level above 500 mg/m3.

4.9.8.2. Economic impact of option 2

Installation of SNCR for achieving an emission level below 500 mg/m^3, is resulting in mean specific total costs of 0.4-0.5 € per tonne of clinker. For SCR installation aiming at the same emission level, specific costs of about 1.0 € per tonne of clinker are reported (calculating with a depreciation period of 20 years and capital costs of 10 %, see chapter 4.8.9).[181]

On this background, it is most probable that SNCR will be the most favoured technique to comply with an emission limit of 500 mg/m^3 because it comprises fewer costs in most cases.

SCR may be installed by cement plants if lower NOx emission levels of e.g. 300 mg/m^3 or less are required.

Additional primary measures may be implemented if costs can be decreased simultaneously, e.g. by using animal bone meal. Process control of combined staged combustion and SNCR is difficult to achieve and will therefore only be applied if additional effects like installations for waste feeding to pre-calciners will simultaneously reduce energy costs. As these measures are at least cost-neutral, they will not be included in the following calculations.

At all existing cement plant types but long kilns and wet process kilns SNCR can be installed successfully for achieving a NOx emission level below 500 mg/m^3. In long kilns and wet process kilns, mid-kiln firing systems can be

[181] compare chapter 4.8.8

installed comprising costs of about 2.5 m Euro per plant and specific costs of about 0.14 Euro per tonne of clinker. Assuming cement costs of 50-80 Euro per tonne, mid-kiln firing causes an increase of cement price of 0.2-0.3 %. No data about the number of long kilns or wet process kilns in Europe are available.[182] It is assumed that 8-9 kilns are existing wet or long kilns co-incinerating waste. If they aim at co-incinerating waste under option 2, an investment of 20-23 m Euro has to be realised to obtain NOx emission levels below 500 mg/m^3.

The implementation of option 2 may have a negative effect on investment cycles as for achieving a NOx emission level below 500 mg/m^3 a relative high capital of about 500-750,000 Euros for SNCR installation per plant has to be bound (see chapter 4.8.9).

The realisation of SNCR investment in all affected 250 cement kilns in EU 27 will amount to a total investment of about 125-188 m Euros.

If 8 wet or long kilns also co-incinerate waste and become subject of a limit value of 500 mg/m^3, the investment in SNCR at 242 kilns and mid-kiln firing at 8 kilns results in a total investment of about 141-201 m Euro.

The binding of relevant capital is expected to have no negative effects on EU internal competition because implementation will be done at a defined and calculable moment, simultaneously and equal to a great majority of kilns in EU 27.

No other negative effect on competition in the internal market is expected because a level playing field for cement industry in EU 27 is created by implementing option 2 to a relevant majority of plants.

The affected 250 kilns comprise about 70 % of the total number of 360 kilns operating in EU 27 in 2007. It is roughly estimated that the affected plants produce 70 % of the total production of about 267.5 m tonnes cement (reported for EU 27 in 2006 [BREF C+L 2007]), equivalent with about 187.3 m tonnes of cement and 150 m tonnes of clinker (supposing a clinker rate of 80 %).

Based on this data, implementation of SNCR with mean total costs of 0.4-0.5 € per tonne of clinker will lead to total additional costs of **75-94 m Euro** per year for implementing option 2 in EU 27.

Implementing option 2 by mainly installing SNCR leads to an increase of the cement price of about 0.5-1.0%,[183] based on a price of 50-80 Euros per ton.

This increase is not considered as a relevant negative effect regarding international competition with plants of non-EU countries which at that time are not subject to similar requirements on existing cement plants co-incinerating waste. International competition is only a threat for a few plants because carrying out global trade (e.g. shipping cement from Sweden to Canada) is only economically viable for a small number of plants located near sea sides or big rivers.

[182] Wet process kilns are reported to contribute with about 2.5 % to European cement production [BREF C+L 2007], without specification about their situation in EU 27 or other Europe (about 18,300 tons per day, about 8-9 kilns).

[183] compare chapter 4.8.8

Therefore a very low number of plants would be affected. Relocation of economic activity (cross border investment flow) is not expected.

Increasing operational costs may lead to increase of imports from Eastern Europe affecting local market conditions in specific regions (EU 27 frontier countries). Therefore negative effects will be mainly restricted to countries like Finland, Poland, Romania and Bulgaria. It is assumed that about 10 existing cement kilns of the total of about 318 existing kilns would be affected (< 5 %).

The increase of cement prices is regarded as having a relatively small effect on trade but may be of relevance to some consumers, intending to invest in private housing.

A positive effect for private market of suppliers of waste gas abatement techniques is expected due to broader markets (providers mainly originate from Austria, Germany, Switzerland and UK). This can result in positive effects for research and development and innovation of environmental protection techniques.

Advantages are expected for owners of large production facilities (due to the effect of economy of scale and because investment costs for waste gas abatement is relatively higher for small production sizes). Most production sizes are between 500 and 5000 tonnes per day. CEMBUREAU [2006-3] reports that a "typical" production size is 3000 tonnes per day, and very few plants have production capacities below 500 tonnes per day. No detailed data on the number of small plants is available. However, the number of affected small plants is considered as relevant, especially because the negative scale effect will be noted predominantly in small installations that anyway have less investment potential. It is assumed that about 5 small plants are affected by option 2.

Negative effects on smaller installations may lead to loss of jobs if these installations are not able to compete, due to higher production costs, arising from elevated expenses for NOx abatement.

In general, no relevant cost impact is expected for competent authorities, as enforcement and monitoring effort is similar to the actual effort.

Option 2 is not expected to have a negative effect on the macroeconomic environment because it is supporting the creation of a level playing field.

Actual trade off effects by increasing waste use in cement plants and decreasing disposal/energy recovery in dedicated waste incinerators are slowed down (current trade off effect is enhanced by high environmental restrictions on NOx emissions in dedicated waste incinerators being obligated to implement NOx levels below 200 mg/m3).

4.9.8.3. Environmental effects of option 2

The implementation of option 2 (setting a NOx emission limit value of 500 mg/m^3 for existing plants) will have a significant environmental benefit.

Positive effects will result on air quality, which in its turn has positive effects on water quality, reduces environmental risks, and improves animal health, biodiversity, as well as flora and fauna. On soil, the implementation of the option has a positive effect because less acidification results.

To quantify the environmental effect, the NOx emission reduction of option 2 is estimated using the same methodology as applied for option 1. For 2004, the mean of annual average values of NOx emissions from 258 kilns was reported with 785 mg/m^3. [CEMBUREAU 2006-2], [BREF C+L 2007]

It is supposed that the implementation of option 2 will lead to a mean NOx emission level of 450 mg/m^3 for all kilns having to comply with a NOx emission limit value of 500 mg/m^3.

Existing kilns assumed to co-incinerate waste in 2013 and not performing with BAT associated emission levels in 2007 are supposed to amount with 250 kilns. About 68 kilns are assumed to already perform with an average NOx emission level of 350 mg/m^3 due to national regulations, including three kilns in Sweden with levels around 200 mg/m^3 and more than 20 kilns with at least 60 % co-incineration in Germany complying with limit values $\leq$ 330 mg/m^3 in 2008.

The following emission levels and numbers of kilns are expected:

Table 99: Effect of option 2 related to average annual emission levels with 10 % BAT level implementation

Option 2	Total	Kilns having a NOx level < 500mg/m^3	Kilns with current NOx level of > 500mg/m^3
Share of total	100 %	21 %	79 %
Number of kilns	318	68	250
2004 emission level	~785	~350	~903
2013 emission level	~428	~350	~450

The reduction of the mean value from 785 mg/m^3 to 428 mg/m^3 is equivalent to a NOx reduction of **45 %**.

In 2004, cement production in EU 25 was 234 million tonnes [CEMBUREAU 2006-3]. Assuming a clinker rate of 80 %, clinker production in EU 25 was 198.9 m tonnes in 2004.

EPER data for 2004 reveal NOx emissions of 345,845 tonnes for the 230 plants of cement industry (NACE code 26.51). [EPER 2004], [CEMBUREAU 2006-3]

Regarding the fact that plants of Bulgaria and Rumania are missing in EPER 2004, and some large plants have not reported to EPER or not under NACE code 26.51 (e.g. choosing code 26.50, see [UBA 2007]), it is assumed that total NOx emissions of cement industry was about 360,000 tonnes in 2004.

In a rough estimation it is supposed that the NOx reduction is linear to the reduction of the yearly average NOx emission level. Under this condition, the calculation above results in a reduction of 357 mg/m^3 between the average NOx emission level in 2004 and the expected average NOx emission level in 2013 which is equivalent to a NOx reduction of 45.4 %, or about **163,400 tonnes** of NOx reduction until 2013.

According to EcoSense [EcoSense 2004], calculating with the value of life year lost concept (VOLY), using a median value of 52,000 Euro and a mean value of 120,000 Euro (according to the Clean Air for Europe project [CAFE 2005]), the effect of a NOx emission reduction of 163,400 tonnes in EU 27 results in an **annual environmental benefit (including health benefit) of 413-697 million Euros**.[184]

Cross-media effects may result from implementing option 2 because NOx reduction will be obtained by ammonia injection. The use of ammonia for SNCR leads to cross-media effects due to the use of energy for ammonia production, delivery, mixing, transport and injection. This leads to the additional use of non-renewable resources for energy production with negative effects on the climate. Cross-media effects are also expected due to the risk of rising ammonia emissions by ammonia injection for NOx abatement with SNCR.

4.9.8.4. Social effects of option 2

The implementation of option 2 results in significant health benefits after 2010 in EU 27 and in neighbouring countries.

The emission reduction leads to health benefits, described under environmental benefit (compare chapter above).

Option 2 can be considered as a measure of good administration because damage of public health is avoided. The implementation of the measure is able to increase public confidence in the co-incineration of waste.

Little negative impact on employment and labour markets is expected because a level playing field is achieved for plant operators of existing cement plants and negative labour market effects may only occur in small installations due to relatively higher impact of investment needs and increased operation costs.

Considering impacts on worker’s health by implementing option 1, negative effects are possible, as SNCR technique is mainly operated with ammonia (urea is used but less effective). Cement plant operators may be exposed to risks when handling ammonia during loading and maintaining.

[184] based on 75,000 € per life year lost

4.9.9. Comparison of options

The analysis has shown that **318 existing cement kilns** out of a total of 360 kilns operating in EU 27 are expected to practice **co-incineration** in 2013 and will therefore fall under the WID. The year 2013 was chosen for comparison of the effects of both options because it is considered as the earliest possible date for possible WID amendments to come into effect.

The analysis has shown that no effect can be expected for about 68 existing cement kilns already performing with a NOx emission level below 500 mg/m^3 due to national regulations (in Austria, Germany and Sweden). Hence, the effect of the options is compared for about 250 affected existing kilns (70 % of the total number of kilns expected in operation in 2013).

The effects of the "Business as usual" scenario depend significantly on the question how competent authorities will implement the WID and the IPPC Directive (BREFs) as regards NOx emission levels. It is assumed that a majority of permits will include the minimum requirements of the Waste Incineration Directive and the minimum NOx emission limit value of 800 mg/m^3 currently required for existing cement plant will be set.

Under option 1, two scenarios are calculated with their corresponding effects. The first one assumes that 10 % of the permits of the 250 affected kilns will achieve an emission limit of 500 mg/m^3; this results in an average NOx emission level of about 450 mg/m^3. For the remaining 90 % of the 250 kilns, average emission level of 750 mg/m^3 will be achieved (corresponding to an emission limit value of 800 mg/m^3). The second scenario calculates with the same emission levels, but assuming that 30 % of the permits will have 500 mg/m^3 as emission limit value and the other 70 % of the permits have a limit value of 800 mg/m^3.

Under option 1 "business as usual", a level playing field for cement industry will not be supported and negative implications for the internal market are expected in EU 27 because of different levels and times of implementation of the IPPC Directive.

Under option 2, the flexibility to set permit conditions is restricted by a lower WID emission limit value, thus causing less distortion of the internal market.

In option 2, all existing kilns co-incinerating waste will be subject to the same minimum requirement of a limit value of 500 mg/m^3 (daily) from 2013 on. It is assumed that an average NOx emission level of 450 mg/m^3 (yearly) will be achieved by implementing option 2.

It is assumed that for both options emission reduction will be achieved mainly by SNCR, with a low probability of using SCR or primary abatement techniques (except if the later support aims like cost reduction, e.g. by using bone meal as waste fuel). Therefore, in the analysis economic effects are only calculated for SNCR. For the calculation, it is presumed that investment costs of SNCR are similar, independently from the level of 800 or 500 mg/m^3 to be achieved.

If option 1 is implemented with 10 % of the permits considering BAT levels, 65,900 tonnes of NOx will be reduced with investment costs of 125-188 million Euros, implying total annual costs for plant operators of 40-48 million Euros and providing environmental and health benefits of 167-281 million Euros.

If option 1 is implemented with 30 % of the permits considering BAT levels, 87,500 tonnes of NOx will be reduced with investment costs of 125-188 million Euros, implying total annual costs for plant operators of 44-54 million Euros and providing environmental and health benefits 221-373 million Euros.

If option 2 is realised, 163,400 tonnes of NOx will be reduced with a total investment of 125-188 million Euros, implying total annual costs for plant operators of 75-94 million Euros, and providing environmental and health benefits of 413-697 million Euros.

Table 100: Effects of both options regarding NOx limit values for existing cement plants

	Option 1		Option 2
	Additionally 10 % with ELV of 500 mgm³ or less	**Additionally 30 % with ELV of 500 mg/m³ or less**	**Additionally 70 % with ELV of 500 mg/m³ or less**
NOx reduction 2013	65,900 t/y	87,500 t/y	163,400 t/y
NOx reduction (%)	18.3 %	24.3 %	45.4 %
Annual total costs (investment + operating)	40 - 48 m Euro	44 - 54 m Euro	75 - 94 m Euro
Envir.+health benefits	167 - 281 m Euro	221 - 373 m Euro	413 - 697 m Euro

4.10. Analysis of impacts of specific provisions regarding the use of high calorific waste in blast furnaces

4.10.1. Problem definition

Presently some 50 000 tonnes of high calorific waste are used in blast furnaces in Europe with a perspective that this amount will rise within the next 3 years to some 350 000 tonnes. In a medium perspective the amount can rise to 500 000 t/y - 800 000 t/y.

Questions have been raised on how to apply the WID effectively with the background of the specific technical situation of a blast furnace. Existing permits show a heterogeneous picture of approaches which have been developed and where it is partly questionable whether the WID-provisions have been transposed to the situation of blast furnaces in the right way. No homogeneous implementation of the WID can be observed in the Member States.

One element of this situation is the fact that this process differs from most of the other thermal processes that are covered by the WID. No direct emissions result from the blast furnace process itself because the off gas is a carbon monoxide rich mixture which is used as energy carrier in subsequent processes (see process description in chapter 4.10.1.1) (this is similar to gasification and pyrolysis processes). Those subsequent processes where the “off gas” is (co-)incinerated (e.g. power plant) are often not on the same site, not run by the same operator or not under the same environmental permit.

In practice the effect of the high calorific waste on the concentration of regulated substances in the incineration off gas is often hardly detectable because the contribution of the high calorific waste to the off gas is relatively small. Thus, enforcement of the emission targets of the WID is very difficult (if not impossible) because the effect from the waste disappears in the variations of the emissions resulting from the primary raw materials and primary energy carrier[185] (e.g. for heavy metals, see chapter 4.10.1.2).

4.10.1.1. Description of the process

Together with other raw materials the iron oxide that is to be reduced in the furnace is fed into the top of the furnace.

In the lower part of the furnace, heated compressed air (hot blast) with temperatures of up to 1 300°C (pressure up to 3.5 bar, mostly enriched with oxygen) is fed through jets (“tuyeres”). Fine coal, fuel oil or high calorific wastes can be fed on the same level as the hot blast.

[185] Nevertheless the overall volume flow of off gas from the use of high calorific waste in blast furnaces that must be regulated according to the WID requirements has a relevant size of 3.5 to 6 bn m^3 per year in a mid term perspective.

The gases from the hot blast and gases from oxidised energy carriers move through the blast furnace and leave the installation as "Blast Furnace Top Gas" (BTG) at the top of the furnace. It has a relatively high CO concentration. When it leaves the blast furnace it has a temperature of around 250°C to 350°C. In most of the cases it is cleaned in a two stage abatement. The first stage (dry deposition) is most often a cyclone. The second stage (wet deposition) is in most cases a wet scrubber. In the Iron and Steel BREF, such multi-stage top gas cleaning is stated as "technique to consider in the determination of BAT" for European integrated steel plants. The concentration of dust in the cleansed gas typically ranges between <1mg/m^3 and <10mg/m^3. Dust and sometimes sludge from the top gas cleaning are re-fed to the processes in integrated steel plants.

Table 101: Composition of blast furnace top gas

Blast furnace	*1	*1	*1	*1	*2
CO	24.7 %	25.5 %	26.5 %	22.5 %	20-28%
CO_2	20.4 %	18.9 %	18.6 %	22.9 %	17-25%
H_2	4.1 %	7.3 %	7.2 %	4.3 %	1-5%
Lower calorific value	3.55 MJ/Nm^3	4.05 MJ/Nm^3	4.2 MJ/Nm^3	3.3 MJ/Nm^3	2.7-4 MJ/Nm^3

*1: [VoestAlpin 2007b]
*2: [Iron & Steel BREF p.176]

The heating of the air (blast) prior to feeding it into the furnace is done in a cow-per. Here the blast furnace top gas together with other gases like natural gas or coke oven gas is burned.

Typically blast furnace top gas is utilised also in power plants, steel mills and coke ovens.

4.10.1.2. Mass and volume flows in a blast furnace

Blast furnaces in Europe are large installations with high mass flows. For every tonne of pig iron around 2 tonnes of total material input are processed. 0.45 to 0.5 tonnes of this input are high calorific materials. The use rate of high calorific waste can be between 0.03 t and 0.08 t per tonne of pig iron.

1 200 to 2 000 m^3 of blast furnace top gas occur per tonne of pig iron [Iron & Steel BREF p.176][186].

As an example of a concrete installation, where the ranges of mass flows are narrowed down compared to the numbers given in the BREF the following table gives the example of an Austrian steel producer.

[186] The calorific value is stated as ranging from 2.7 to 4 MJ/m3 [I&S BREF p.176]. The average energy output is between 4 400 to 5 000 MJ/t pig iron via the blast furnace gas [I&S BREF p.183].

Table 102: Material consumption in four blast furnaces

Blast furnace	No.4	No. 5	No. 6	A
		Mass flows		
Production	2 127 t/24h	2 271 t/24h	2 207 t/24h	7 728 t/24h
Sinter	460 kg/$t_{PIG\ IRON}$	532 kg/$t_{PIG\ IRON}$	534 kg/$t_{PIG\ IRON}$	640 kg/$t_{PIG\ IRON}$
Pellets	656 kg/$t_{PIG\ IRON}$	721 kg/$t_{PIG\ IRON}$	739 kg/$t_{PIG\ IRON}$	500 kg/$t_{PIG\ IRON}$
Iron ore	338 kg/$t_{PIG\ IRON}$	292 kg/$t_{PIG\ IRON}$	287 kg/$t_{PIG\ IRON}$	473 kg/$t_{PIG\ IRON}$
Recycling materials	104 kg/$t_{PIG\ IRON}$	61 kg/$t_{PIG\ IRON}$	51 kg/$t_{PIG\ IRON}$	1 kg/$t_{PIG\ IRON}$
Hot blast	93 000 Nm^3/h	91 200 Nm^3/h	91 900 Nm^3/h	315 500 Nm^3/h
Coke	401.2 kg/$t_{PIG\ IRON}$	411.7 kg/$t_{PIG\ IRON}$	426.6 kg/$t_{PIG\ IRON}$	356.6 kg/$t_{PIG\ IRON}$
Fuel oil	45.7 kg/$t_{PIG\ IRON}$	35.1 kg/$t_{PIG\ IRON}$	35.7 kg/$t_{PIG\ IRON}$	64.9 kg/$t_{PIG\ IRON}$
Coke oven gas	---	54.1 kg/$t_{PIG\ IRON}$	52.8 kg/$t_{PIG\ IRON}$	---
Others	---	---	---	22.3 kg/$t_{PIG\ IRON}$

[VoestAlpin 2007]

Different high calorific materials can be used to deliver the necessary energy for the reduction of the iron ore. The following figure shows 6 examples of combinations of high calorific materials used in practice.

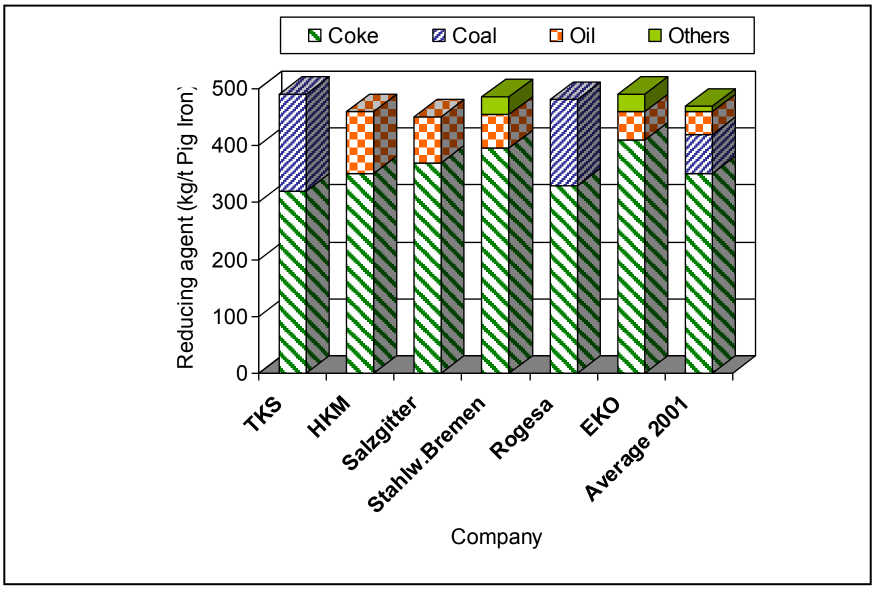

Figure 13: Consumption of reducing agents in some blast furnaces [Buchwalder 2003]

Figure 13 depicts the mass and volume flows in an integrated steel plant. Around 90% of the blast furnace top gas results from other sources than high calorific wastes. In the subsequent co-combustion this gas is mixed with other energy carriers and air for the combustion process. This “dilution” makes it almost impossible to detect whether the concentration of pollutants in the off gas from the waste is higher than intended according to the C_{waste} value which is used in the mixing rule to determine the ELV (value “C”). Very often the contributions from the high calorific waste to the concentration of substances in the off gases are hidden in the “normal” variations of emission situation (the “background noise”).

4.10.2. Objective of the policy options

The objective of the policy options is to provide a basis in the European legislation that ensures a homogeneous approach for permitting the use of high calorific waste in blast furnaces in Europe. Achievement of the environmental targets of the WID shall be ensured taking into account, inter alia, practical enforceability of the provisions and potential (extensive) monitoring efforts[187].

4.10.3. Policy options

The following options on how to regulate the usage of high calorific wastes in blast furnaces have been included in the analysis of the impacts. An additional option has been considered where the environmental targets of the WID are solely achieved via input related requirements based on BAT. However, since the Iron&Steel BREF document does not include information to support this, this option has been excluded from the assessment.

Business as usual option (BAU)

This option is taken as a reference option only. The actual approach taken in the Member States will differ from it and varies from case to case as described in chapter 4.10.1.

In this option it is assumed that the WID is applied in a way that the emission limit values of Annex V of the WID (after applying the mixing rule) and the measurement requirements are applied for the cowper and all other plants where the BTG is (co-)incinerated.

It is further assumed that all exemptions from measurement requirements according to Article 11 of the WID will be utilised[188]. However, continuous measurement of dust, CO, NO_x and SO_2 is performed anyhow even without the use of waste both at cowper and power plant. In accordance with Article 11 of the WID two discontinuous measurements of HCl and HF are performed per year, Cd+Tl, Hg, Sum heavy metals is measured one time per two years and PCDD/F is measured one time per year.

Measurement that fulfil the monitoring requirements of WID Article 6 and Article 11.3 (operation conditions) are being monitored anyhow even without the use of waste.

The requirements of Article 8 of the Directive are applied to waste water from wet BTG cleaning.

187 Background: "dilution" effects, where the off gas from the thermal treatment of high calorific waste is mixed with gas flows resulting from the process (not waste related) and the use of BTG from one blast furnace in several installations and the related monitoring efforts.

188 From this, it should not be concluded that all plants will automatically qualify for such exemptions

Option 1 Simplified baseline

In this option only the cowper off gas is monitored in accordance with the WID in spite of the fact that blast furnace top gas is also co-combusted in other installations (e.g. power plants as exemplary installation in this option). This approach is included in the analysis with the following background:

- Most of the BTG is co-combusted in cowpers Typically, cowpers have very simple off gas abatement systems, if any. Thus it can be assumed that if the waste related emission levels are achieved in the off gas from the cowper they will also be achieved in the other installations.
- It is taken into consideration that cowpers are part of the integrated steel plants while other plants where the BTG is co-combusted are often isolated plants or plants with individual permits outside of the integrated steel plant.
- In power plants the BTG makes up only a low percentage of the sum of energy carrier[189]. Thus in those installations the contribution of the high calorific waste that is used in the blast furnace to the emissions e.g. at the power plant is even more difficult to detect.

Compared to scenario 1 the only difference is that no measurements of HCl, HF, heavy metals and PCDD/F must be performed in the power plant.

Option 2 Input limitations

In this option the set of instruments of the WID is extended by the instrument of "Input Limitations". The concentration of certain substances in the high calorific waste that is used in the blast furnace is limited in a way that the emission limit values of the WID can not be exceeded. No additional monitoring will be required as long as those minimum requirements regarding the composition of the input wastes are met.

Limits for input concentrations will be set for the parameters heavy metals, chlorine, fluorine and sulphur. Other parameters like TOC, NO_x, PCDD/F and CO are largely influenced by the combustion conditions in the installations where the BTG is co-combusted and not or not so much by the composition of the high calorific waste. It is assumed that no significant change in these parameters in the cowper results from the use or non-use of waste.

The application of the mixing rule of the WID generally results in a lower emission limit values compared to the situation without waste use (see Table 103 in chapter 4.10.4.3). In this context it must be taken into account that the dust in the cowper off gas results only to a very small extent from the waste. This results from two facts:

189 In most of the cases cowpers are run with an input that consists to more than 90% of BTG.

- The ash content in the high calorific waste is relatively low (for well treated plastic waste from shredder light fraction the ash content is at around 10% [VW 2005]).
- The waste is introduced via the tuyères in the lower part of the blast furnace and only a very small portion of the mineral content of the waste will make its way through the blast furnace into the BTG.

In case the high calorific waste makes up less than 1% of the total process input it is assumed that far less than 1% of the emitted dust results from the high calorific waste.

In this option the concentrations of pollutants are restricted in the input waste in a way that the ELV of the WID are met for those pollutants. Hence, the amount of pollutants bound to dust can be expected to be below the amount corresponding with the ELV of the WID.

From this point of view, the dust ELV form the WID can be dropped and set at the level of C_{proc} (as C value). The amount of off gas from the waste depends on the composition of the waste. When two wastes are used that have the same concentration of heavy metals but different percentages of carbon and/or hydrogen, the concentrations of heavy metals in the off gas will be different. In this scenario the lower calorific value of the waste is taken as an approximation to the off gas volume (see also figure in the Annex 3 to this report).

A quality management system for the input waste is a prerequisite of this scenario. Those systems will be in place anyhow when high calorific waste is used because of the technical requirements of the blast furnace process and the requirements regarding the quality of the product “pig iron” as well as the requirements regarding the properties of the slag. Most of the necessary activities resulting from the quality management will be done by the waste provider. The costs are already included in the prices for the waste as described in chapter 4.10.4.5 and page 286). The additional costs for the steel producer are negligible.

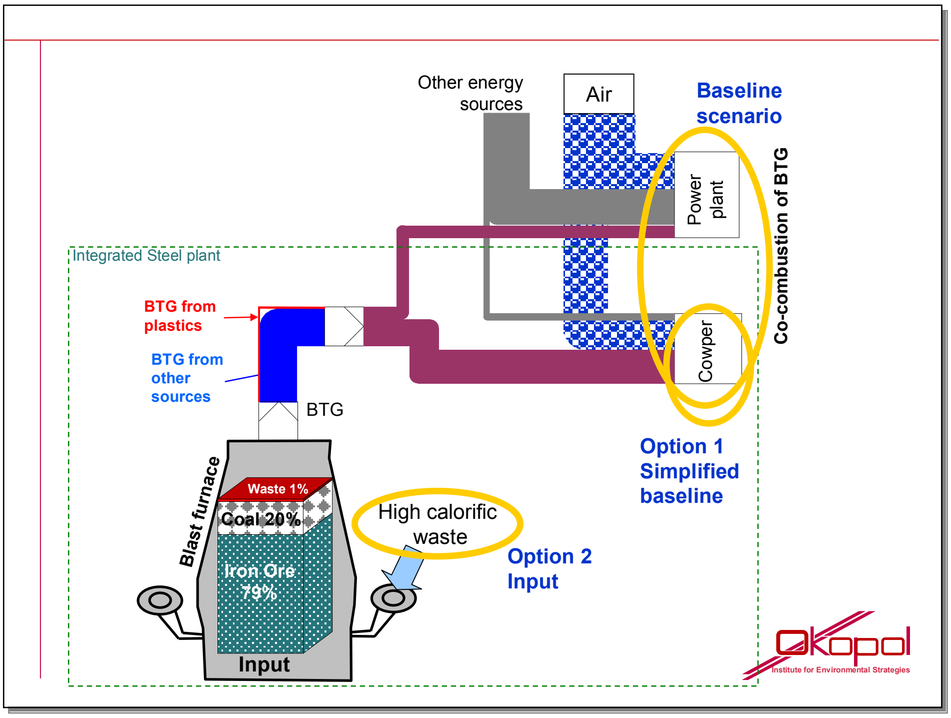

Figure 14: Visualisation of options

4.10.4. Analysis of impacts

4.10.4.1. Procedural aspects

For the impact analysis the following steps have been undertaken:

- Identification of priority impact categories;
- Screening the impacts to identify which impacts are relevant for which stakeholder group (business, consumers, public authorities) and the environment;
- Qualitative description of the impacts;
- Quantification of the impacts (where data availability allows to do so).

Data has been used from literature study, own expertise, consultation with individual companies and experts and European industry association.

4.10.4.2. Identification of priority impact categories

From screening of possible impact categories with regard to economic impacts incidence of the impact categories competitiveness, trade and investment flows, operating costs and conduct of business, administrative costs on businesses and public authorities are expected. Because impacts in the internal market are not expected to be significant, this, in turn, will entail limited impacts under the impact categories property rights, innovation and research, consumers and households, specific regions, third countries and international relations and the macroeconomic environment.

Relevant environmental impact categories are air quality and the likelihood or scale of environmental risks and potentially water quality. Limited impacts are expected regarding soil quality or resources, climate, renewable or non-renewable resources, biodiversity, flora, fauna and landscapes, land use, waste production /generation / recovery mobility (transport modes) and the use of energy, the environmental consequences of firms' activities as understood in the impact assessment guidelines SEC(2005) 791 and animal and plant health, food and feed safety.

Regarding social impacts no or minor impacts are expected for the categories standards and rights related to job quality, social inclusion and protection of particular groups, equality of treatment and opportunities, non –discrimination, private and family life, personal data, governance, participation, good administration, access to justice, media and ethics, crime, terrorism and security and access to and effects on social protection, health and educational systems. Impacts are possible regarding the category employment and labour markets. The category public health is considered in this analysis together with environmental aspects.

4.10.4.3. Detailing of the scenarios

Mass and volume flows and emission limit values for all scenarios

For all options assessed in the impact assessment the following parameters for the use of high calorific waste will be applied:

- The specific amount of plastic waste is $60kg/t_{pig\ iron}$[190].
- The combustion gas volume (dry) from the combustion of the blast furnace top gas resulting from the high calorific waste (V_{waste}) is calculated as $454\ Nm^3/t_{pig\ iron}$[191].
- The combustion gas volume (dry) from the combustion of the top gas resulting from the other reducing agents ($V_{process}$) is calculated as $3801\ Nm^3/t_{pig\ iron}$[192].
- C_{waste} is defined in Annex V of the WID.
- C_{proc} for the cowper is described according to the national ELV or, where this is not available, according to ELV from the permit of exemplary plants.

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[190] This complies with the amounts used in a German blast furnace since several years.

[191] calculation based on [DEFRA 2006]

[192] calculation based on [DEFRA 2006]

The application of the mixing rule to this scenario results in the ELV shown in the following table (daily averages, input = 100% BTG). Regarding the value "C" different O_2 concentration compared to C_{proc} must be taken into account. The "C"-value of the parameter dust for example is largely influenced by the higher O_2 concentration of the value "C" (11%O_2) compared to the O2 concentration of the value C_{proc} (3%).

Table 103: Emission limit values for combustion of blast furnace top gas in a cowper applied as a basis for the impact analysis

Parameter	C_{proc} (mg/Nm³)	Comment	C_{waste} (mg/Nm³)	C (mg/Nm³) (11% O_2)	Comment
Total dust	10	d	10	6,05	
NO_x	500	d	200	269,17	
SO_2	500	d	50	252,56	
CO	1000	c	50	499,57	
TOC	150	c	10	75,21	
HCl	30	d	10	15,93	
HF	5	d	1	2,58	
Cd +Tl	0,05	e	0,05	0,05	a
Hg	0,05	e	0,05	0,05	a
Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V	0,05	e	0,5	0,5	a
Dioxins & furans	0,1(ng/Nm³)		0,1(ng/Nm³)	0,1(ng/Nm³)	a

a) C-value from WID Annex II.3, no application of the mixing rule (11% O_2)

c) C_{proc} value for one exemplary German plant that is currently using high calorific waste as secondary reducing agent (3%O_2)

d) German TA Luft Nr.- 5.4.3.2a (general pollution protection regulation) 5mg dust per m³ are permitted in another steel plant (3%O_2)

e) actual emission value of two cowpers in integrated steel plants (3% O_2)

- The blast furnace uses a two stage gas cleaning: dry separation of dust in a cyclone and wet cleaning in a scrubber. The de-dusting of the BTG works with an efficiency of 99.75%[193]. A simple de-dusting step (e.g. cyclone, 1 field ESP) is applied for the off gas cleaning of the cowper.
- The composition of the BTG before combustion in the cowper is shown in the following table.

Table 104: Composition of blast furnace top gas

Parameter	Concentration
CO	25 %
CO_2	20 %
H_2	4 %
Lower calorific value	3.5 MJ/Nm³

[I&S BREF, VoestAlpin 2007]

- From combustion air a dilution effect of 25% results when the BTG is combusted.

193 Calculated based on concentration data from [I&S BREF], [ARCELOR pers.com. 2007]

- 80% of the chlorine input, 15% of the lead input, 20% of the cadmium input and 100% of the Hg input is transferred into the raw BTG.
- The cleaning efficiency for the BTG treatment is 99.5% for chlorine, 99.7% for lead, 99% for Cd and 90% for Hg.
- The most important parameters for the analysis of environmental aspects are:
    - Compared to other installations where wastes are incinerated or co-incinerated blast furnaces and the subsequent cowper have a relatively simple waste gas treatment (see chapter 4.10.1.1). No specific elements for the removal of certain volatile heavy metals and organic hazardous substances are applied in European blast furnaces (see e.g. [I&S BREF 2001]).
    - Reports from trials where plastic waste has been used give account for increase in organic hazardous substances in the water and/or sludge from BTG cleaning [DBU 1997].
    - Comparisons of the compositions of plastic wastes with the compositions of coal, fuel oil and coke show increasing input of chlorine in the blast furnace process when plastic substitutes primary energy carriers. Fluorides and sulphur are of low relevance in plastic waste.

  Concluding the parameters Hg, Cd, Pb, Cl, PAH are seen as most relevant parameters.

4.10.4.4. Economic impacts

Description of the industry sector, waste amounts and number of plants affected

84 blast furnaces were operating in 2004 in EU25 with a maximum production output of ~ 111 million tonnes [WVStahl 2006]. All existing installations are covered by the IPPC Directive. The following figure shows the development of pig iron production in recent years.

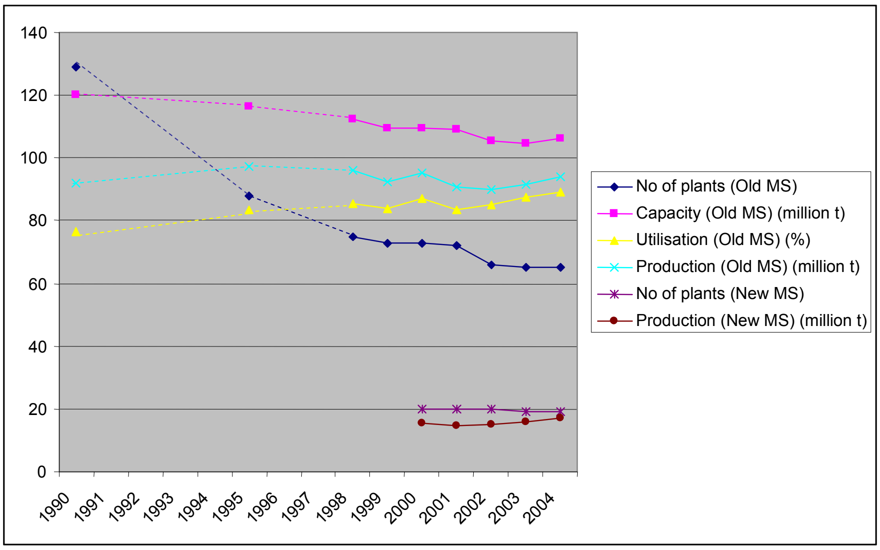

Figure 15: Pig iron production in the European Union [WVStahl 2006]

A first rough estimation of the potential amount of high calorific wastes to be used in blast furnaces in the EU can be based on specific use rates as achieved in recent trials and in installations that already use this kind of wastes.

EKO Stahl Germany has recovered plastic waste since 1997 (~25 000 t/y). Stahlwerke Bremen (Germany) used around 50 000 t/y for 10 years but stopped its use in 2006. VoestAlpin (Austria) has a permit for the use of ~200 000 t/y (since 2007). Salzgitter Stahl (Germany) owns a permit for the use of ~70.000 t/y but does not make use of it yet. Experience is also available from Japan (NKK Corp.)

[Kepplinger 2005] states specific use rates for plastic wastes between 40.3 and 65.0 kg/t pig iron in three plants. The Iron and Steel BREF mentions 0 to 30 kg[194].

Based on these numbers, a theoretical waste usage potential of 3 to 7.5 million tonnes per year could be estimated[195]. The actual usage of high calorific wastes in the primary steel production is, however, influenced by a multitude of limiting factors which are, on the one hand, determined by the process itself. On the other hand, external factors like availability of appropriate waste, reliability of delivery and price levels must also be considered. In total a maximum medium-term potential of 500 000 t/year to 800 000 t/year can be estimated that could be used in Europe[196].

194 It must be assumed, however, that this is not a description of the possible amount, but of the amounts actually used at this date.

195 See also table in the Annex to this report.

196 Basis: Expert interviews performed between May and July 2007

In a short term perspective it can be assumed that 2 plants in Germany will use waste (one already under operation and one with a valid permit and existing installations) and one plant in Austria (valid permit and existing installation). Taking the availability of appropriate high calorific waste into account it can be assumed that three to four additional mid sized plants can start using waste in Europe. One could be located in South Europe and two in western Member States. For the impact analysis a scenario with 5 plants using 100 000 tonnes each per year is applied.

General cost aspects of the use of plastic waste in blast furnaces

For the use of high calorific waste appropriate storage and transport units must be built and the tuyères must be reconstructed or additional tuyères must be fit. Information about the investment costs is very rare and not very well proven. For the use of 50 000 t plastic waste per year in one steel plant the investment costs of ~10 million € have been estimated[197]. For a 200 000 t installation where 2/3 of the installation has been realised investment costs of 20 million € have been estimated.

For the use of plastic waste in the blast furnace of Stahlwerke Bremen the German DSD[198] made additional payments of up to 100 € in the first use period to Stahlwerke Bremen and reduced its payments over the years. This economic situation was very much triggered by a situation where DSD must achieve certain recycling rates for packaging waste[199] and few appropriate recovery paths have been available.

Presently the supply of high calorific mixed plastic waste is still higher than the demand by appropriate recovery facilities. This results not least from the fact that landfilling of high calorific wastes is increasingly prohibited in Europe. Payments by the supplier of the waste to the steel plants are assumed to be presently between zero and 40 €/t.

In a mid term perspective some expect that the steel plant has to pay 20 € to 50 € per tonne of plastic waste [Pilz 2007].

High calorific waste substitutes coal or fuel oil. The prices of coal and fuel oil vary widely and are very much influenced by the increasing costs for energy carrier in recent years and by individual contracts of the companies. As an average price of coal 80 €/t and of fuel oil 100 €/t are used in this analysis.

While availability of actual cost data for the use of high calorific waste in blast furnaces is limited four scenarios have been calculated. The price for high calorific waste that is applicable in the blast furnace process has been set between minus 2 cents per kilogram and plus 2 cents per kilogram (meaning that in the first case 2 cents per kilogram are paid to the blast furnace company and in the

197 Detailed investment costs have not been disclosed by the plant operator.

198 German compliance system fort he implementation of the packaging ordinance

199 In Germany the use of plastic in blast furnaces is seen as recycling.

latter case 2 cents per kilogram must be paid by the blast furnace company; see above in this chapter regarding the background of price developments in recent years). The price for the substituted reducing agent is between 8 cent and 10 cent per kilogram. The specific use rate is set between 30 kg/$t_{pig\ iron}$ as a minimum and 80 kg/$t_{pig\ iron}$ as currently known maximum for the use of high calorific wastes (see chapter 4.10.1.2 regarding the differences in the use of reducing agents). 1 kg of high calorific waste substitutes in this calculation 0.8 kg reducing agent. Cost savings for substituted reducing agents of 1.8 to 6.7 €/$t_{pig\ iron}$ have been estimated[200].

Table 105: Costs and saved costs for primary and secondary reducing agents

		Scenarios			
		I	II	III	IV
Price of high calorific waste	€/kg	-0,02	-0,02	0,02	0,02
Price of substituted reducing agents	€/kg	0,08	0,08	0,1	0,1
Use rate of secondary reducing agent	kg/t of pig iron	30	80	30	80
Costs for plastic granulates	€/t of pig iron	-0,6	-1,6	0,6	1,6
Saved costs for substituted reducing agent*	€/t of pig iron	1,92	5,12	2,4	6,4
Total saved costs for substituted reducing agent	**€/t of pig iron**	**2,52**	**6,72**	**1,8**	**4,8**

* 1 kg of high calorific waste replaces 0.8 kg primary reducing agent

Payback periods for investments have been described in expert interviews as between three years and ten years[201].

4.10.4.5. Analysis of economic impacts

Option 1 shows a reduction of costs (compared to the BAU option) resulting from the reduced monitoring efforts (no monitoring at power plant) of ~8 000 €/year per plant[202].

Option 2 includes the same cost reduction from avoided monitoring at the power plant as option 1. In addition reduced costs result from the fact that no additional off gas cleaning must be performed at the cowper. As a basis for the calculation of saved costs it is assumed that the relatively small reduction of the emission concentrations that is necessary in option 1 (~1 mg/m^3; see Table 103 showing the results of the mixing rule) can be achieved by relatively simple dedusting equipment (e.g. one field ESP) resulting in costs of 140 000 € per year for a blast furnace with a capacity of 2.5 million tonnes of pig iron per year and a use of 100 000 tonnes of high calorific waste per year[203 204]. Additional relevant

200 No capital costs are considered here

201 Payback periods of three to four years appear to be realistic in the case of two German blast furnaces.

202 Non performance of 2 measurements of HCL per year, one PCDD/F measurement per year and one measurement of Hg, Cd+Tl and sum of heavy metals per two year resulting in costs of ~9000EUR per year [ECOLAS 2007]. No investment costs occur for periodic measurements. Where the power plant is not part of the integrated steel work the reduction of costs will occur for the power plants.

203 Investment costs for an ESP for 1.25 million m^3/h = 1.2 million Euro, depreciation 10 years, interest rate 4%, operating costs = 15000 EUR per year. Costs of installation are not considered.

costs for monitoring of input waste qualities are not expected for option 2 since a detailed monitoring will be done anyhow (see chapter 4.10.3).

Concluding it can be estimated that option 2 leads to a cost reduction for 5 steel plants that use high calorific waste of around 745 000 € per year compared to the BAU option[205], which is 1.5 € per tonne of waste.

Information for the quantification of costs and administrative efforts for the WID permit is not available. However according to the estimations of [ECOLAS 2007] the costs for WID permitting would make up a very small part of the overall economic impact.

The reduced costs of options 2 can be a factor that improves competitive position of blast furnaces that use high calorific waste in comparison to their competitors. Same is valid for option 1 but to a smaller extent. However, just 5% to 10% of the blast furnaces in Europe or a similar percentage of pig iron production will be affected from the cost minimisation effects.

Further differences between the options regarding operating costs and conduct of business will not occur.

Impacts on SME are not considered here because all European integrated steel plants are large enterprises.

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204 This refers to cases where no dust abatement system is in operation behind the cowper. In case that an existing dust abatement system must be improved the costs will be lower. However, quantification needs the consideration of the individual cases.

205 5 plants with 100 000 tonnes of plastic waste each

Table 106: Economic impacts of the analysed scenarios for 5 plants using 500 000 t of high calorific waste per year

	Option 1 "Simplified baseline"	Option 2 "Input"
Main element	**Restriction of measurements to cowper**	**Limitation of concentrations of certain substances in input waste in the WID permit**
Investment costs	No differences compared to BAU scenario[206]	Reduced costs for off gas cleaning equipment of 745 000 €/y for 5 plants
Operating costs	Reduced costs of ~40 000 €/year for 5 plants compared to BAU scenario because no measurements must be performed at the power plant	Reduced payments / increased costs for high calorific waste[207] Reduced costs because of reduced off gas measurements: operating costs of 40 000 €/y at steel plant and 40 000 €/y in power plant (as in option 1) Reduced operating costs for off gas cleaning equipment of 75 000 €/y for 5 plants. Overall yearly cost reduction of 705 000 €/y for 5 plants
Administrative costs on businesses	Minor reduction of administrative efforts resulting from reduced meas-urements at power plant (no data available for quantification)	Compared to option 1 further reduced administrative efforts resulting from reduced measurements at cowper
Administrative burden for public authorities	negligible (Reduced administrative efforts result-ing from reduced measurements)	negligible (Compared to option 1 further reduced administrative efforts resulting from reduced measurements)
Impacts on the internal market	No differences are expected because the same requirements are valid for all plants in the EU	
Innovation and research	Only minor differences of the effects on innovation and research expected compared to BAU scenario	Effects on innovation and research could be higher than in scenario BAU if more waste is used because of reduced costs
The macroeconomic environment	No differences of the effects expected	

4.10.4.6. Environmental impacts

It is the basic assumption for the BAU scenario and both options that in principle the emission limit values of the WID are met (regarding the parameter "dust" see discussion below). In option 1 this is achieved by off gas abatement sys-tems and in scenario 2 this is achieved by limiting the concentration of certain substances in the input waste. The risk that the emissions from the use of high calorific waste will be higher than in other installations where a similar "dilution" effect and difficult monitoring situation don't exist is highest in the BAU scenario and option 1. Due to this one of the objectives of the WID could be missed that says: "The co-incineration of waste in plants not primarily intended to incinerate waste should not be allowed to cause higher emissions of polluting substances in that part of the exhaust gas volume resulting from such co-incineration than those permitted for dedicated incineration plants and should therefore be sub-ject to appropriate limitations" [Recital 27 of the WID].

206 The differences regarding the measurement requirements are restricted to discontinuous measurements where no significant investment costs are necessary.

207 The price for the high calorific waste will increase with the reduction of contaminations because of higher treatment costs. The effect that separation of contaminations like chlorine results in lower supply of waste is not considered here because the supply of plastic waste is still bigger than the demand. No additional costs are expected for waste quality management system because this will be established anyhow in order to ensure compliance with the specifications set by the waste user.

The risk of higher concentrations of pollutant in the off gas resulting from the high calorific waste does not differ significantly between option 1 and the BAU option because of the specific emission situation at cowpers and power plants and the off gas monitoring situation as analysed in chapter 4.10.3 under "Option 1".

Option 1 will result in lower dust emissions (see chapter 4.10.3 under "Option 2" for explanations) that sum up to 20 t per year from 5 plants. However, it has to be noted that this dust results to a very small extent from the high calorific waste. More than 99% of the emitted dust is dust from other input materials.

Table 107: Environmental impacts of the analysed scenarios

	Option 1 Simplified baseline	**Option 2 Input**
Main element	**Restriction of measurements to cowper**	**Limitation of concentrations of certain substances in input waste in the WID permit**
Air quality	Similar emission level as in BAU scenario.	Higher dust emissions compared to scenario BAU and option 1 (at least ~20t/y[208], however, this dust result only to a very small extent from high calorific waste).
Water quality and resources	No differences of the emissions.	
Waste production / generation /recycling	It is unlikely that recovery of waste in blast furnaces will be hampered because it is expected that the costs differences as discussed above have little effect on the use of high calorific waste in blast furnaces. Vice versa no differences between the options are seen regarding the effects on other forms of recovery of high calorific waste.	Depending on the actual threshold values the limitation of concentration in the input waste can lead to increased pre-treatment costs and reduced supply of appropriate materials. However, probably the effect is not relevant in case of the input related requirements as described above and the amounts of high calorific wastes as considered in this impact analysis.
The likelihood or scale of environmental risks	Measuring the relatively small effect from the use of waste will face the problem that the effects disappear in the fluctuations of the overall emissions and the very "diluted" portion of the waste gas resulting from the waste. This is considered as a risk that the emissions from the use of waste in this installation are higher than in other installations where the "dilution" effect does not occur (see also recital 27 of the WID). The risk is considered to be similar in BAU scenario and option 1. The ELV for the installation (the value "C") is however not considered to be exceeded. No monitoring of waste related emissions at the power plant can be considered as additional risk. However, because of the "dilution effect" reliable monitoring at the power plant would hardly be possible. Thus the additional risk is considered to be very small.	The option "input" can only be realised for parameters like heavy metals, HCl, HF, SO_2. Other parameters like NO_x and CO are largely influenced by the combustion conditions in the cowper and not or not so much by the composition of the waste. This is considered as increased risk of emissions higher than in other plants where the "dilution" effect does not occur. Compared to option BAU and option 1 the risk is not higher[209]. The risk of higher concentrations of pollutants in the off gas resulting from the waste does not exist in this option as it is the case in BAU option and option 1. This is considered as reduced risk.

[208] 8 million t of pig iron produced in the installations that use the high calorific waste, 4000 m^3 off gas per t of pig iron, difference in emission values = 4 mg/m^3

[209] The likeliness of measurable PCDD/F emissions is seen as low because of the physical situation in the blast furnace, the BTG cleansing system and the additional subsequent combustion of the BTG.

4.10.5. Comparison of options

Compared to the option BAU option 1 leads to a reduction of costs of around 40 000 € per year for 5 plants which is a specific saving of 90 cent per tonne of waste or 0.5 cent per tonne of pig iron produced in the 5 plants.

Option 2, where compliance with the emission limit values of the WID is achieved by limitation of contaminants in the input waste results in cost savings compared to BAU option of around 745.000 €/y for 5 plants which is 1.5 € per tonne of waste used in the 5 plants or 10 cents per tonne of pig iron produced.

Because option 1 includes a dust abatement system that also separates dust that does not result from the waste itself it leads to an overall reduction of dust emissions of around 20 t per year.

Option 2 on the other hand enables the limitation of pollutants in the off gas flow from the waste better than option 1 because the practical enforcement of limitation of concentrations via monitoring of off gas (as in option 1) is difficult to realise. This is considered as reduced risk that the objective of the WID as cited in its recital 27 (same pollutant concentrations in the off gas resulting from the incineration and co-incineration of waste independently from the type of installation) is not achieved.

In the context of option 2 it has to be considered that measuring heavy metal concentrations in heterogeneous waste is challenging and a highly developed comprehensive quality management system is necessary to ensure that concentration limits are not exceeded in the input waste.

4.11. Specific provisions for the expanded clay industry

4.11.1. Introductory remark

Within the ceramic sector waste is co-incinerated in the expanded clay industry. The use of waste in other sub-sectors (e.g. in brick industry) is generally not permitted in Member States as co-incineration of waste but is considered to be a recovery operation. However, often there is an energy contribution from such material to the process.

4.11.2. Description of sector and process

The following description is mainly based on the information submitted by the Association of Expanded Clay Industry (European Expanded Clay Association EXCA) between March 2007 and June 2007. EXCA represents 14 companies in the following 13 countries: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany (2 producers), Italy, Norway, Poland, Portugal, Spain and Sweden. EXCA companies produced in 2005 about 7 000 000 m^3 expanded clay lightweight aggregates (=~90% of the volumes in EU and EFTA) in 28 rotary kilns at 19 plants.

According to EXCA, most kilns are "either in the permitting process (6 kilns) or re-permitting process (9 kilns)" [EXCA pers.com. June 2007]

Expanded clay lightweight aggregates are manufactured from naturally occurring clay, which is expanded in rotary kilns at temperatures between 1100 and 1300 ºC.

The specific thermal energy consumption of an expanded clay kiln varies between 900 and 1300 MJ/m^3 expanded clay aggregates depending on the raw material, production technology, and production capacity [BREF Ceramic 2006].

According to EXCA fuel represents up to 1/3 of the production costs.

4.11.3. Use of waste in the expanded clay industry

Organic waste is used for two different main functions in the expanded clay industry. On the one hand it serves as an expansion additive resulting in the porous structure of the material. On the other hand it is used as fuel.

The use of additives can contribute (partly significantly) to the energy budget of the process[210].

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210 In Austria, Germany and Italy, where most houses are built with lightweight blocks, the consumption of fuels in the production process is relatively low resulting in an energy consumption from fuels of 1.1 – 1.9 GJ/tonne. "The lower density of the blocks is reached by the presence and/or the addition of pore-forming materials to the clay. These materials are mostly organic substances. They contribute to the energy balance of the clay brick production and, therefore, the specific primary energy consumption (natural gas, liquid fuel) is low" [BREF Ceramic p. 102]

In 2005 about 225 000 tonnes of waste were used as alternative fuel in EXCA's members kilns. The substitution rates of the kilns that presently co-incinerate waste are as follows:

- 45% kilns 0-25% substitution rate
- 10% kilns 25-50% substitution rate
- 30% kilns 50-75% substitution rate
- 15% kilns 75-100% substitution rate

A European average of the substitution rate is not available.

No data are available about the type of waste used as fuels in the expanded clay industry. Based on the information from EXCA that at some plants the thermal substitution rate from the use of hazardous wastes is above 40% it can be expected that the amount of co-incinerated hazardous waste is considerable.

4.11.4. Emission situation of the expanded clay industry

According to the BREF document for the Ceramic Industry the main parameter influencing the air borne emissions is the composition of the raw materials.

In addition to differences in the process and off gas abatement technologies this is a factor why a broad range of emission levels can be observed in this industry sector

The BREF document also states that the "use of organic pore-forming agents may result in increased emissions of organic substances and CO to the air" [Ceramic BREF p.143].

Organic additives such as sawdust and polystyrene[211] give rise to VOC emissions. "The generation of VOC emissions can, in principle, be avoided by switching to inorganic pore-forming additives,…" However, as a cross-media effect "minimisation of organic compounds in raw materials may increase energy consumption for the firing process" [Ceramic BREF p.153].

4.11.5. Description of the problems

The stakeholder described the following problems with the implementation of the WID:

a) the mixing rule is not always applied in a proper way according to WID: It was reported by the stakeholder that in 5 plants (7 kilns) plants the emission limit values of Annex V of the WID are applied without considering the mixing rule even in those cases where less than 40% hazardous waste is co-incinerated.
According to the stakeholder three plants (5 kilns; one not in operation) had applied for emission limit values based on the calculation and definition

[211] These materials can be but must not necessarily be waste.

given in Annex II of WID.

b) Usually no C_{proc} value is available for the parameter TOC and CO. It is reported by the stakeholder that there are no emission limit values in the permits of expanded clay plants as long as no waste is co-incinerated. When the plant applies for a WID permit the permitting authorities have to apply a TOC level based on a plant specific reference value. A common emission value for several plants would not be feasible because the emission situation in the plants vary widely depending on the raw materials and additives used in the plant. According to the stakeholder a clear guidance is missing on how to develop such a reference value.

No further details and/or exemplary cases could be made available by the stakeholder[212]. Information requests to the individual plants have been answered with a link to the European association and the need for an approach coordinated on European level.

Based on the available information basis no reliable and precise description of option for solving the problem can be elaborated.

[212] On June 4th EXCA wrote in a letter to Ökopol: "Sufficient reliable data on TOC, CO and SO2 emission is not available, and can not be provided within the short time span of the brought forward review study. Consequently a proposal with thorough justification on special provisions for expanded clay kilns in Annex II.3 of the WID can not be given."

4.12. Lime industry

In November 2007 EULA delivered a proposal for setting a value C_{proc} in an Annex to the WID which provides specific requirements for the co-incineration of waste in the lime industry. Due to the late delivery no further analysis could be performed and the input is reflected here without further commenting.

European Lime Association

Association Européenne de la Chaux • Europäischer Kalkverband

2006 fuel questionnaire consolidated as %

Type of fuel	Fuel description	Energy amount	LRK	PRK	ASK	PFRK	MFNSK	OSK	All kilns
Gas (fossil)	Natural gas, coke oven and converter gas, butane/propane gas	%	3%	29%	68%	60%	2%	67%	43%
Solid (fossil)	Coal, anthracite, petcoke, metallurgical coke, lignite	%	82%	58%	7%	23%	98%	24%	41%
Liquid (fossil)	Heavy, medium and light fuel oil	%	4%	2%	11%	8%	0%	2%	6%
Waste (fossil and biomass)	Waste wood, tyres, plastics, waste liquid fuel, animal fat, meat and bone meal	%	11%	11%	14%	7%	0%	6%	9%
Biomass	Wood, wood chips, sawdust, residues from agriculture and forestry	%	0%	0%	0%	2%	0%	0%	1%
			100%	100%	100%	100%	100%	100%	100%

European Lime Association

Association Européenne de la Chaux • Europäischer Kalkverband

1. INTRODUCTION

In the frame of the revision of the WID, Eula is proposing to create an Annex II.3 for the determination of ELV specific dust, NO_x, SO_2 for the lime industry. This document is proposing process related emissions values C_{proc} to be used in the following formula:

$$\frac{V_{waste} \times C_{waste} + V_{proc} \times C_{proc}}{V_{waste} + V_{proc}} = C$$

- C: resulting ELV that applies
- C_{waste}: emission limit for incineration plants (Annexe V)
- V_{waste}: gas volume resulting from incineration
- C_{proc}: emission level specific to process
- V_{proc}: gas volume resulting from non-waste fuels

C_{waste} are defined in Annexe V of the WID.

2. Cproc PROPOSAL

Dust – Nox – SO2

All values at 11% O_2, dry gas basis

$NO_x = NO_2$ equivalent

2.1 For Soft burned lime

LIME KILNS		Cproc in mg/Nm3, 11% O2 dry Dust	NOx	SO2
Long Rotary Kiln	LRK	50	700	800
Preheater Rotary Kiln	PRK	50	1000	300
Annular Shaft Kiln	ASK	50	500	400
Parallel Flow Regenerative Kiln	PFRK	50	400	300
Mix Feed Shaft Kiln	MFSK	50	400	300
Other Shaft Kilns	OSK	50	400	300

SO_2: in case of high sulfur content of feed stone, Emission Limit Values to be set case by case by the competent local authorities.

2.2 Mid Burned and Hard burned lime/dolime

Emission Limit Values to be set case by case by the competent local authorities.

2.3 Other Pollutants

Emission Limit Values to be set case by case by the competent local authorities.

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