Emissions of Persistent Organic Pollutants in Iceland 1990 - 2008

Informative Inventory Report 2010

Submitted under the Convention on Long Range Transboundary Air Pollution

UMHVERFISSTOFNUN

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Preface

The Convention on Long Range Transboundary Air Pollution (CLRTAP) was adopted in 1979 and entered into force in 1983. The Convention has been extended by eight Protocols, of which Iceland has ratified the Protocol on Persistent Organic Pollutants.

According to Article 8 of the Convention, Parties shall exchange information on emissions of pollutants. To comply with this requirement, Iceland has prepared an Informative Inventory Report (IIR) for the year 2010. The IIR together with the associated Nomenclature for Reporting tables (NFR) is Iceland's contribution to this round of reporting under the Convention, and covers emissions in the period 1990 – 2008. This report covers mainly emissions of Persistent Organic Pollutants, as Iceland has only ratified the Protocol on Persistent Organic Pollutants. Emissions of the indirect greenhouse gases (NO_x, CO, NMVOC) and SO_2 are provided in the NFR tables for information purposes, as they are calculated to comply with the reporting requirements of the UNFCCC. A short description of the trends of those pollutants are given in this report, but a description of the calculation method is not provided.

The IIR is written by the Environment Agency of Iceland (EA).

Environment Agency of Iceland, Reykjavík, June 2010

INDEX OF TABLES

INDEX OF FIGURES

EXECUTIVE SUMMARY

Background

The Convention on Long-Range Transboundary Air Pollution entered into force in 1983. The Convention has been extended by eight Protocols, of which Iceland has ratified the Protocol on Persistent Organic Pollutants (POPs). The Protocol on Persistent Organic Pollutants entered into force in 2003. As a party to the protocol Iceland is required to report annually data on emissions of air pollutants covered in the protocol. This report together with the associated NFR tables covers emissions of POPs (polycyclic aromatic hydrocarbons (PAH) and dioxins) in the period 1990 – 2008. Further a short description of the trend in emissions of NO_x, NMVOC, CO and SO_2 is given.

Trends in emissions and removals

From 1990 to 2008 emissions of PAH4 have increased by 70%. The largest contributor PAH4 emissions in Iceland are industrial processes, followed by road transport.

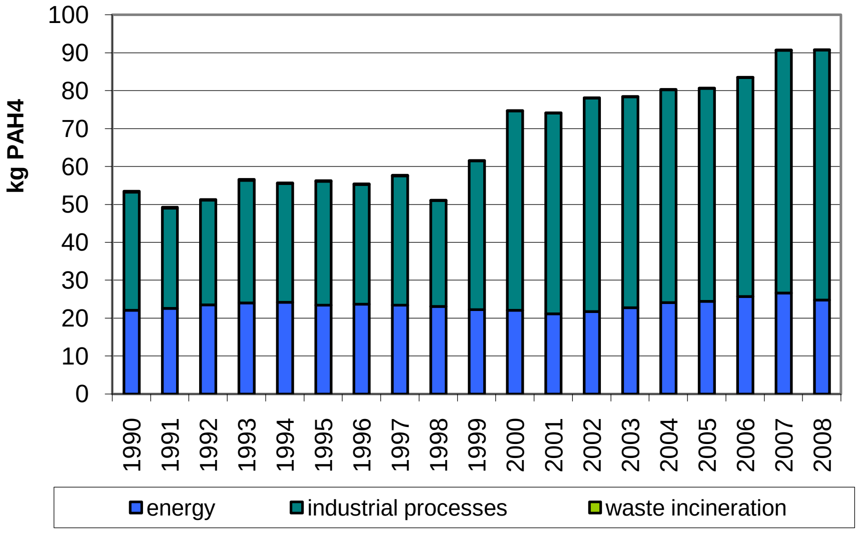

Figure ES.1 Trend in PAH4 emissions from 1990 to 2008.

From 1990 to 2008 emissions of dioxins decreased by 66%. The largest contributor of dioxins emissions in Iceland is waste incineration with and without energy recovery, followed by fishing.

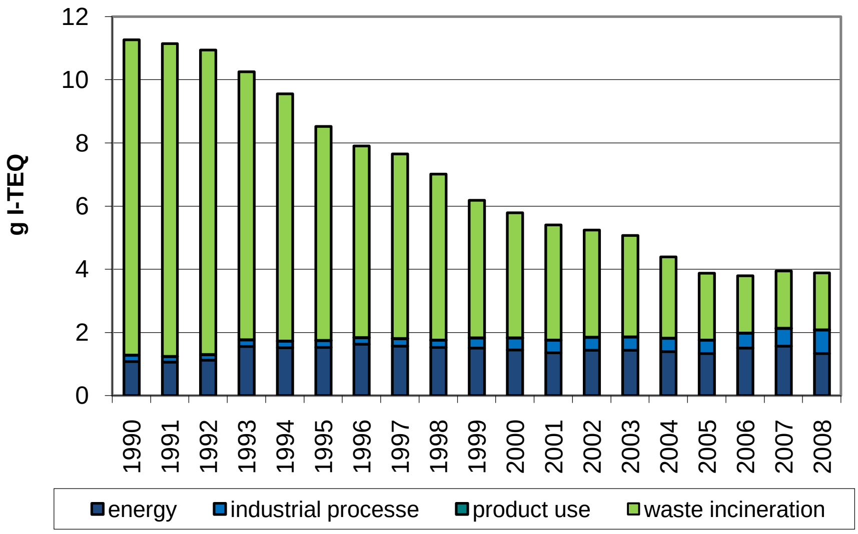

Figure ES.2 Trend in dioxins emissions from 1990 to 2008.

Structure of the report

The first chapter of this report provides general information on the institutional arrangements for inventory preparation, on the inventory preparation process, methodologies and data sources used. Chapter 2 gives information on emission trends and Chapter 3 gives information on methodologies used for emission calculations.

1 INTRODUCTION

1.1 Background information

The 1979 Convention on Long-Range Transboundary Air Pollution was signed by Iceland on 13th of November 1979 and ratified in May 1983. The Convention entered into force in August 1983. One of the requirements under the Convention is that Parties are to report their national emissions by sources.

The Convention has been extended by eight Protocols, of which the Protocol on Persistent Organic Pollutants (POP-Protocol) has been signed and ratified by Iceland. The POP-Protocol was ratified by Iceland in May 2003 and entered into force in October 2003.

The present report together with the associated NFR tables is Iceland's contribution to this round of reporting under the Convention, and covers emissions of PAH and dioxin/furans in the period 1990 – 2008, as well as gridded data for the years 1990, 1995, 2000 and 2005.

Emissions of the indirect greenhouse gases (NO_x, CO, NMVOC) and SO_2 are provided in the NFR tables for information purposes, as they are calculated to comply with the reporting requirements of the UNFCCC. A short description of the trends of those pollutants are given in this report, but a description of the calculation method is not provided.

1.2 Institutional arrangement

The Environment Agency of Iceland (EA), an agency under the auspices of the Ministry for the Environment, has overall responsibility for the national inventory. EA compiles and maintains the emission inventory and reports to the Convention. Figure 1.1 illustrates the flow of information and allocation of responsibilities.

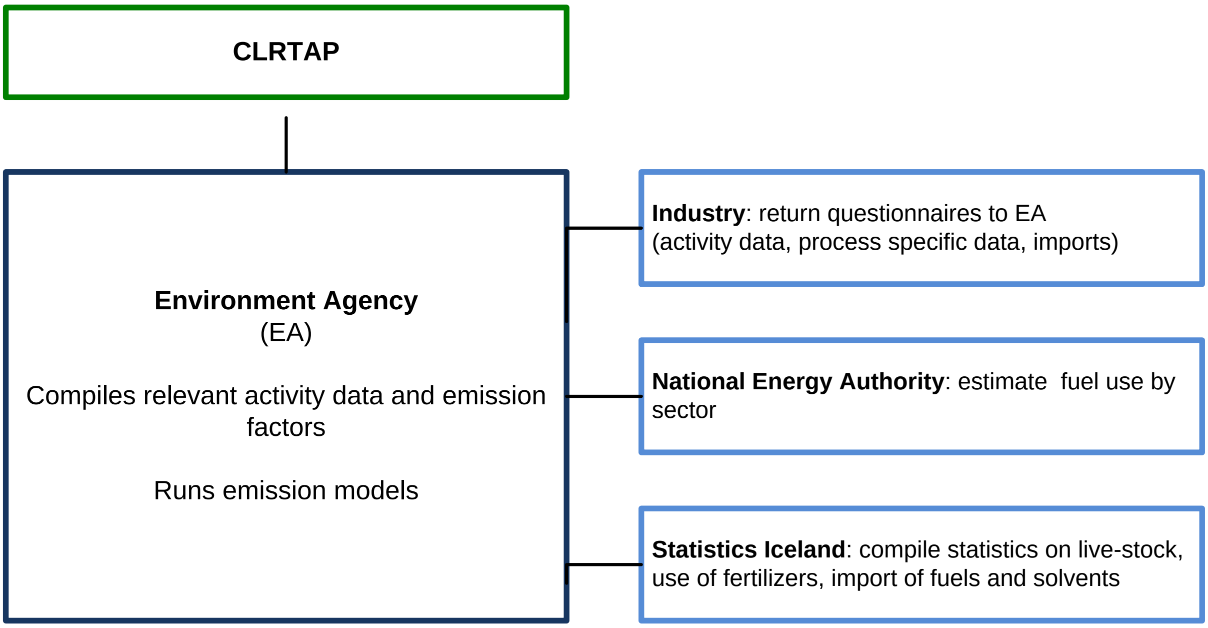

Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the CLRTAP

1.3 Process of inventory preparation

The EA collects the bulk of data necessary to run the general emission model, i.e. activity data and emission factors. Activity data is collected from various institutions and companies, as well as by EA directly. The National Energy Authority (NEA) collects annual information on fuel sales from the oil companies. This information was until 2008 provided on a voluntary basis. New legislation, Act No. 48/2007, enable the NEA to obtain sales statistics from the oil companies. Statistics Iceland provides information on imports of solvents and other products, the use of fertilizers in agriculture and on the import and export of fuels. The EA collects various additional data directly. Annually an electronic questionnaire is sent out to the industry regarding imports, use of feedstock, and production and process specific information. EA also estimates activity data with regard to waste. Emission factors are mainly taken from the revised Emission Inventory Guidebook (EEA 2007), the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2001) as well as the Norwegian reports Utslipp til luft av dioxiner i Norge[1] (Statistic Norway 2002) and Utslipp til luft av noen miljögifter i Norge[2] (Statistics Norway 2001), since limited information is available from measurements of emissions in Iceland.

1.4 Methodologies and data sources

The general emission model is based on the equation:

Emission (E) = Activity level (A) · Emission Factor (EF)

The standard equation for estimating PAH emission factor (example for B[b]F) is:

Emission factor (B[b]F) = Emission Factor (B[a]P) · Profile ratio B[b]F/ B[a]P

1.5 Key source categories

A key source category is one that is prioritized within the national inventory system because its estimate has a significant influence on the total inventory of pollutants in terms of the absolute level of emissions, the trend in emissions, or both.

A key source analysis for reported pollutants from RepDab is provided in Table 1.1.

Table 1.1 Key source analysis for reported pollutants

Component	Key source categories (Sorted from high to low from left to right)							Total (%)
SOx	(79.1%)	2 C 3 (13.7%)	2 C 2 (2.7%)					95.6
NOx	1 A 4 c iii (53.5%)	1 A 2 f ii (12.3%)	1 A 3 b iii (9.9%)	1 A 3 b i (8.7%)	1 A 3 a i (ii) (7.7%)	1 A 3 d ii (5.7%)		97.8
NMVOC	1 A 3 b i (33.8%)	3 A 3 (28.6%)	1 A 3 b ii (8.6%)	1 A 3 b iii (8.4%)	1 A 2 f ii (7.3%)	1 A 4 c iii (6.3%)	1 A 3 a i (ii) (5.3%)	98.3
CO	1 A 3 b i (56.0%)	1 A 3 b ii (15.6%)	1 A 3 b iii (13.7%)	1 A 4 c iii (6.9%)	1 A 2 f ii (5.2%)			97.4
DIOX	6 C c (46.3%)	1 A 4 c iii (16.9%)	1 A 1 a (14.1%)	2 C 3 (13.6%)	2 C 2 (5.5%)			96.3
PAH	2 C 2 (48.0%)	2 C 3 (24.7%)	1 A 3 b i (8.0%)	1 A 4 c iii (7.2%)	1 A 2 f ii (4.9%)	1 A 3 b iii (4.5%)		97.2

[1] Utslipp til luft av dioxiner i Norge: Air emissions of dioxins in Norway
[2] Utslipp til luft av noen miljögifter i Norge: Air emissions of several pollutants in Norway

1.6 Quality assurance and quality control (QA/QC)

The objective of QA/QC activities in national emissions inventories is to improve transparency, consistency, comparability, completeness, accuracy, confidence and timeliness. A QA/QC plan for the annual greenhouse gas inventory of Iceland has been prepared. The document describes the quality assurance and quality control programme. It includes the quality objectives and an inventory quality assurance and quality control plan. It also describes the responsibilities and the time schedule for the performance of QA/QC procedures. The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Source category specific QC measures have been developed for several key source categories. A quality manual for the Icelandic air emission inventory has been prepared. It can be found on http://www.ust.is/media/fraedsluefni/pdf-skjol//Iceland_QAQC_manual.pdf. To further facilitate the QA/QC procedures all calculation sheets have been revised. They now include a brief description of the method used. They are also provided with colour codes for major activity data entries and emissions results to allow immediate visible recognition of outliers.

1.7 Uncertainty evaluation

An estimate of the quantitative uncertainty of the Icelandic POP emission inventory has not yet been prepared.

1.8 General assessment of the completeness

An assessment of the completeness of the emission inventory should address the issues of spatial, temporal and sectoral coverage along with all underlying source categories and activities.

In terms of spatial coverage, the emissions reported under the CLRTAP cover all activities within Iceland's jurisdiction. In this reporting round information is provided on emissions within the EMEP-Grid for the years 1990, 1995, 2000 and 2005.

In the case of temporal coverage, NFR table 1 is reported for the whole time series from 1990 to 2008, for dioxins and PAH4. HCB emissions are not estimated.

With regard to sectoral coverage some sources are not estimated. The reason for not including the activities/gases in the present submission is lack of data, and/or that additional work was impossible due to time constraints in the preparation of the emission inventory.

The main sources not estimated for dioxins are:

- 2A6: Road paving with asphalt
- 6D: Other waste
- 7: Other
- X: Volcanoes

The main sources not estimated for PAH4 are:

- 1A2e: Food processing, beverages and tobacco
- 1A3a: Civil aviation
- 1A3b vi: Automobile tyre and break wear
- 1A3b vii: Automobile road abrasion
- 1A3d i: International maritime navigation
- 1A4a: Commercial/institutional
- 1A4b: Institutional
- 1A5a: Other
- 2A6 Road paving with asphalt
- 2A7: Mineral wool
- 3D: Other
- 6D Other waste
- 7 Other
- X Volcanoes

2 TRENDS IN EMISSIONS

2.1 The 1998 Aarhus Protocol on Persistent Organic Pollutants (POPs)

The Protocol on Persistent Organic Pollutants was adopted on 24 June 1998. It entered into force on 23 October 2003. It focuses on a list of 16 substances that have been singled out according to agreed risk criteria. The substances comprise eleven pesticides, two industrial chemicals and three by-products/contaminants. The ultimate objective is to eliminate any discharges, emissions and losses of POPs. The Protocol bans the production and use of some products outright (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene). Others are scheduled for elimination at a later stage (DDT, heptachlor, hexaclorobenzene, PCBs). Finally, the Protocol severely restricts the use of DDT, HCH (including lindane) and PCBs. The Protocol includes provisions for dealing with the wastes of products that will be banned. It also obliges Parties to reduce their emissions of dioxins, furans, PAHs and HCB below their levels in 1990 (or an alternative year between 1985 and 1995). For the incineration of municipal, hazardous and medical waste, it lays down specific limit values.

2.2 Trends in POPs emission

The total amount of dioxins and PAH4 emitted in Iceland during the period 1990 – 2008 is presented in Table 2.1. It can be seen that emissions of PAH4 have increased by 70% from 1990 to 2008, whereas dioxin emission have decreased by 66% during the same period.

Table 2.1. Emissions of POPs in Iceland 1990 – 2008.

Year	Emission	
	PAH4 [kg]	Dioxin [g I-TEQ]
1990	53.5	11.3
1991	49.3	11.2
1992	51.3	10.9
1993	56.6	10.3
1994	55.7	9.6
1995	56.3	8.5
1996	55.4	7.9
1997	57.7	7.7
1998	51.2	7.0
1999	61.6	6.2
2000	74.8	5.8
2001	74.2	5.4
2002	78.2	5.3
2003	78.5	5.1
2004	80.4	4.4
2005	80.7	3.9
2006	84.6	3.8
2007	90.8	3.9
2008	90.8	3.9
Trend 1990 - 2008	70%	-66%

2.3 Emission trends by gas

2.3.1 **PAH4**

The polycyclic aromatic hydrocarbons (PAH) are molecules built up of benzene rings which resemble fragments of single layers of graphite. PAHs are a group of approximately 100 compounds. Most PAHs in the environment arise from incomplete burning of carbon-containing materials like oil, coal, wood or waste. Fires are able to produce fine PAH particles, they bind to ash particles and sometimes move long distances through the air. Thus PAHs have been ubiquitously distributed in the natural environment since thousands of years. The four compounds benzo(a)pyren, benzo(b)fluoranthen, benzo(k)fluoranthen and indeno(1,2,3-cd)pyren are used as PAH indicators for the purposes of emission inventories, as specified in the POP- Protocol.

In 1990, the total emissions of PAH4 in Iceland were 53.5 kg. In 2008 total emissions were 90.8 kg. This implies an increase of 70% over the time period. Table 2.2 shows the emissions by source from 1990 to 2008.

Table 2.2. Emissions of PAH4 by sector 1990 – 2008, kg.

Year	Energy industries and commercial	Manufacturing industry & construction	Road transport	Other transport	Fishing	Industrial processes	Waste incineration
1990	-	2.9	10.2	0.8	8.3	31.1	0.2
1991	-	2.7	10.7	0.7	8.6	26.4	0.2
1992	-	2.5	10.9	0.7	9.4	27.6	0.2
1993	0.0	2.7	10.7	0.8	9.8	32.4	0.2
1994	0.0	2.8	11.0	0.7	9.6	31.4	0.2
1995	0.0	3.5	9.7	0.5	9.8	32.6	0.2
1996	0.0	3.4	9.2	0.6	10.5	31.6	0.1
1997	0.0	4.1	8.7	0.3	10.2	34.1	0.1
1998	0.0	4.1	8.8	0.3	9.9	27.9	0.1
1999	0.0	4.5	7.8	0.2	9.7	39.2	0.1
2000	0.0	4.6	8.1	0.2	9.1	52.7	0.1
2001	0.0	4.5	8.2	0.3	8.1	53.0	0.1
2002	0.0	4.3	8.4	0.2	8.9	56.3	0.1
2003	0.0	3.9	10.0	0.4	8.5	55.6	0.1
2004	0.1	4.7	10.6	0.6	8.1	56.2	0.1
2005	0.1	5.1	11.0	0.3	7.9	56.2	0.0
2006	0.2	4.6	13.3	0.6	7.0	57.9	0.0
2007	0.2	4.6	13.9	0.8	7.2	64.0	0.0
2008	0.2	4.4	13.0	0.7	6.6	66.0	0.0
Trend 1990 - 2008	-	55%	27%	-8%	-21%	112%	-82%

Figure 2.1 shows the main sources of emissions in 2008.

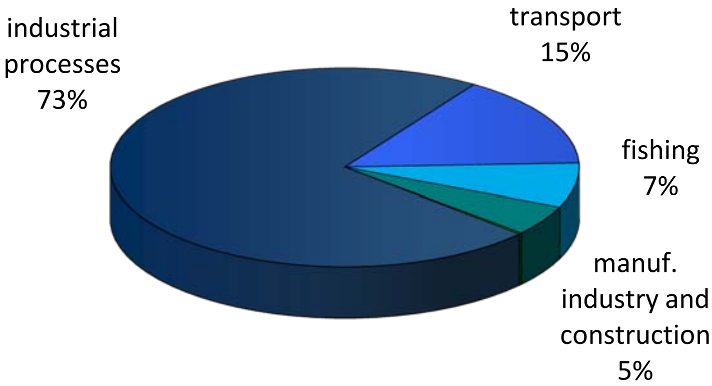

Figure 2.1. Emissions of PAH4 by sector in 2008.

The main reason for the growth in emissions from 1990 to 2008 can be explained by increased production capacity in the non-ferrous metals production sector. In 1990 one aluminium and one ferrosilicon plant were operated. The existing aluminium plant expanded in 1997 and the ferrosilicon plant in 1999. In 1998 a new aluminium plant was established. In 2006 and 2007 that aluminium plant was expanded. In 2007 a third aluminium plant in Iceland was established. Production has thus expanded from 87.839 thousand tonnes in 1990 to 781.151 thousand tonnes in 2008 in the aluminium industry and from 62.792 thousand tonnes in 1990 to 96.407 thousand tonnes in 2008 in the ferrosilicon industry.

By the middle of the 1990s economic growth started to gain momentum in Iceland. Iceland experienced until 2007 one of the highest growth rates of GDP among OECD countries. Late year 2008, Iceland was severely hit by an economic crises when it's three largest banks collapsed. The crisis resulted in serious contraction of the economy, followed by increase in unemployment and a depreciation of the Icelandic króna. The increase in GDP from 1990 to 2007 resulted in higher emissions from most sources, in particular from road transport and the construction sector. The crisis led to collapse of the construction sector in the autumn 2008.

Road transport is an important source of PAH4 emissions in Iceland. Since 1990 the vehicle fleet in Iceland has increased nearly by 81%. Furthermore the trend until 2007 was towards larger passenger cars which consume more fuel. This led to increased emissions from road transportation. Emissions from road transport in 2007 were 36% higher than in 1990. In 2008 fuel prices rose significantly leading to lower emissions from the sector compared to the year before.

Emissions from mobile sources in the construction industry are also significant. Emissions from the construction sector have risen, particularly in recent years (with exception of 2008), due to increased activity in house building in the capital area and the construction of Iceland's largest hydropower plant (built in the years 2003 to 2007). Emissions from construction were 62% higher in 2007 than in 1990, but declined by 4% from 2007 to 2008.

Emissions from fishing rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in distant fishing grounds, consuming more fuel. From 1996 the emissions decreased again reaching 1990 levels in 2004. In 2008, the emissions were 21% below 1990 levels. Annual changes in emissions reflect the inherent nature of the fishing industry.

Emissions from the waste sector have decreased by 82% from 1990 to 2008, partly because of close down of primitive incineration plants and open pit burning. At the same time more waste is being incinerated with energy recovery and the resulting emissions thus reported under the energy industries sector.

Figure 2.2 to 2.5 show emissions of PAH4 within the EMEP-Grid in 1990, 1995, 2000 and 2005.

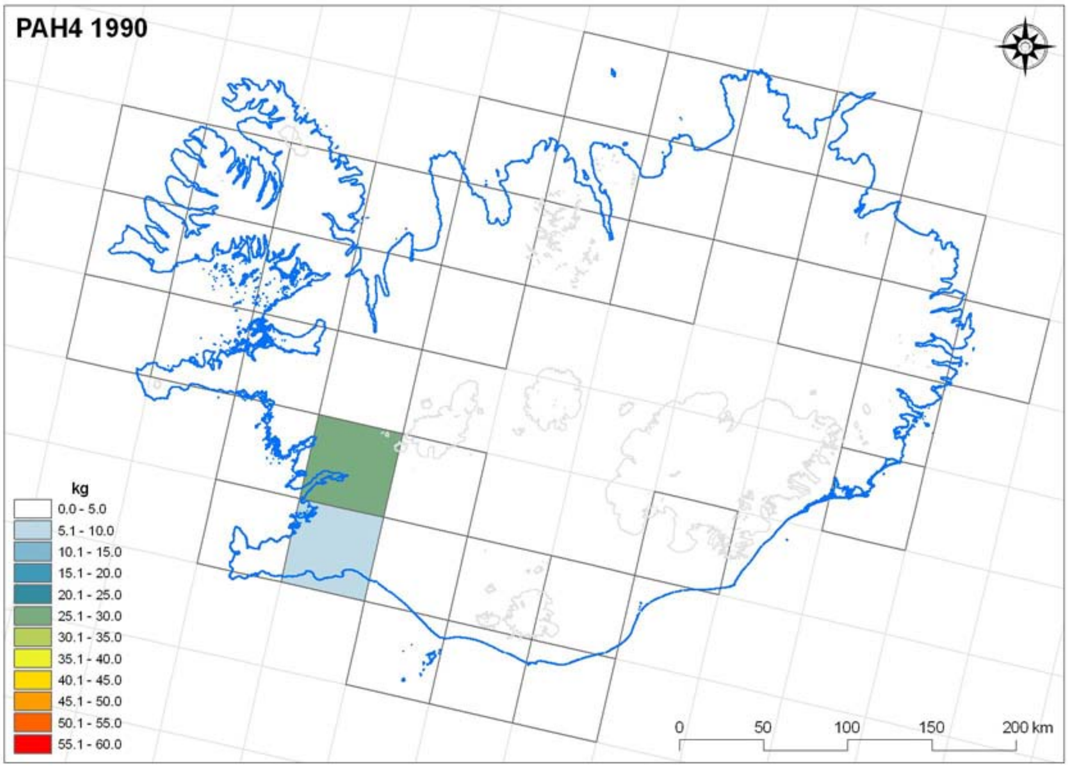

Figure 2.2. Emissions of PAH4 within the EMEP-Grid in 1990.

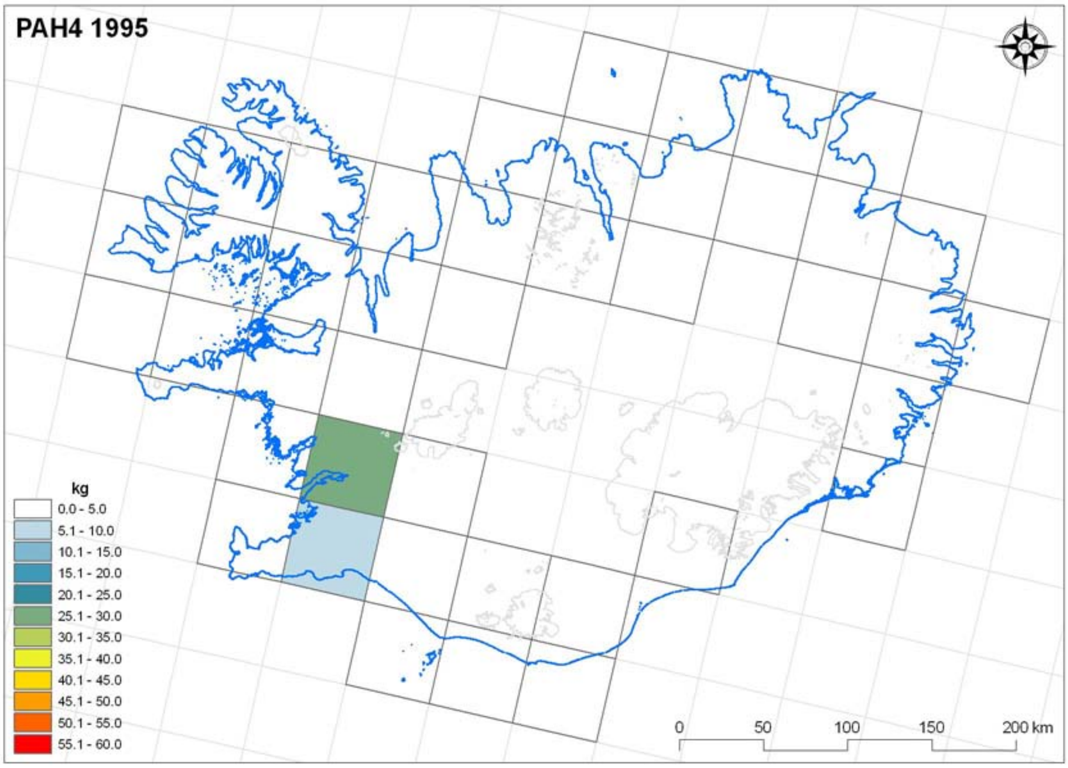

Figure 2.3 Emissions of PAH4 within the EMEP-Grid in 1995.

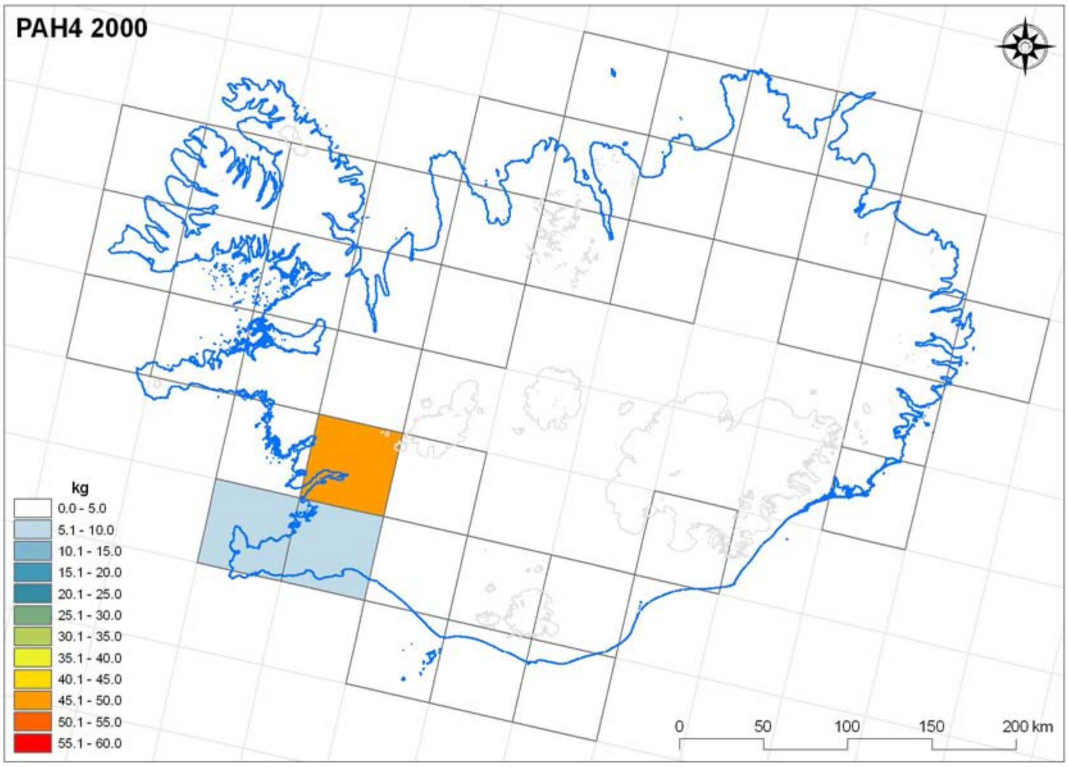

Figure 2.4. Emissions of PAH4 within the EMEP-Grid in 2000.

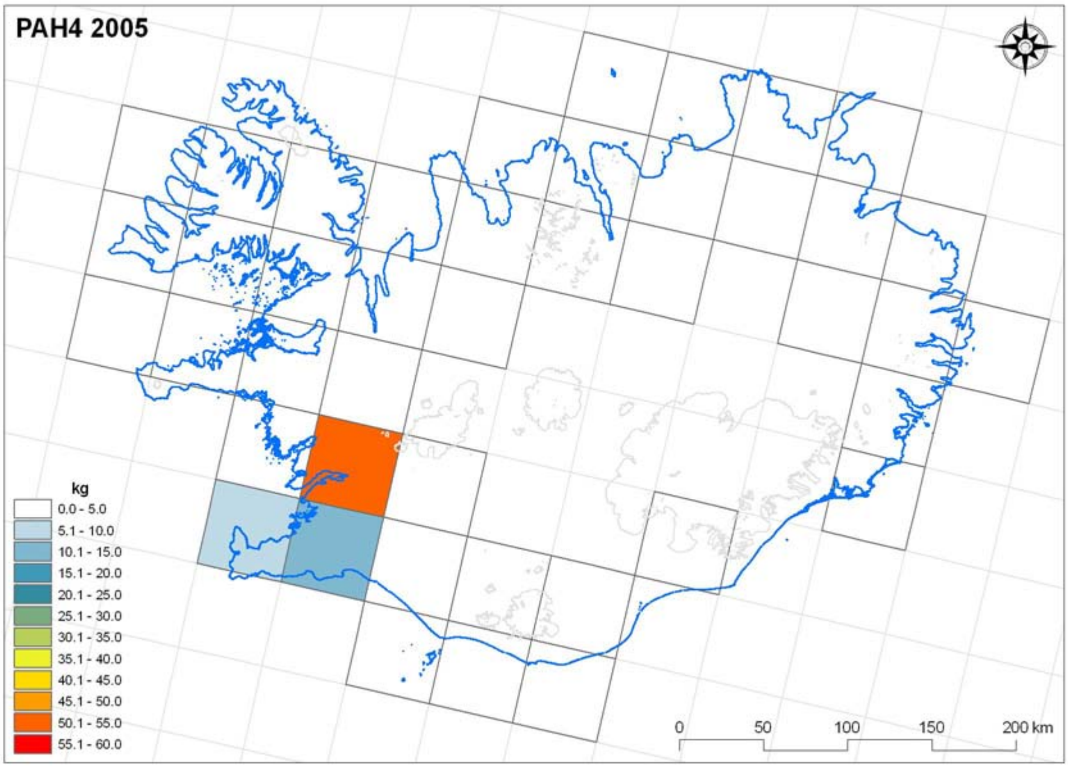

Figure 2.5. Emissions of PAH4 within the EMEP-Grid in 2005.

2.3.2 Dioxin

Dioxins form a family of toxic chlorinated organic compounds that share certain chemical structures and biological characteristics. Dioxins are members of two closely related families: the polychlorinated dibenzo(p)dioxins (PCDDs; 75 congeners) and polychlorinated dibenzofurans (PCDFs; 135 congeners). Dioxins bio-accumulate in humans and wildlife due to their fat solubility and 17 of these compounds are especially toxic. Dioxins are formed as a result of combustion processes such as commercial or municipal waste incineration and from burning fuels like wood, coal or oil. Dioxins can also be formed in natural processes such as forest fires. Dioxins enter the environment also through the production and use of organochlorine compounds, chlorine bleaching of pulp and paper, certain types of chemical manufacturing and processing, and other industrial processes are able to create small quantities of dioxins. Cigarette smoke also contains small amounts of dioxins.

Emissions of dioxins are given in g I-TEQ. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic of the dioxin congeners. Other congeners (or mixtures thereof) are given a toxicity rating from 0 to 1, where TCDD is 1. The total dioxin toxic equivalence (TEQ) value expresses the toxicity as if the mixture were pure TCDD.

In 1990, the total emissions of dioxins in Iceland were 11.3 g I-TEQ. In 2008 total emissions were 3.9 g I-TEQ. This implies an decrease of 66% over the time period. Table 2.3 shows the emissions by source from 1990 to 2008.

Table 2.3. Emissions of dioxin by sector 1990 – 2008, g I-TEQ.

Year	energy industries and commercial	Road transport	Other transport	fishing	industrial processes	waste incineration
1990	0.0	0.1	0.1	0.8	0.2	10.0
1991	0.0	0.1	0.1	0.9	0.2	9.9
1992	0.0	0.1	0.1	0.9	0.2	9.6
1993	0.4	0.1	0.1	1.0	0.2	8.5
1994	0.4	0.1	0.1	1.0	0.2	7.8
1995	0.4	0.1	0.1	1.0	0.2	6.8
1996	0.5	0.0	0.1	1.0	0.2	6.1
1997	0.5	0.0	0.0	1.0	0.2	5.9
1998	0.5	0.0	0.0	1.0	0.2	5.3
1999	0.5	0.0	0.0	1.0	0.3	4.4
2000	0.5	0.0	0.0	0.9	0.4	4.0
2001	0.5	0.0	0.0	0.8	0.4	3.6
2002	0.5	0.0	0.0	0.9	0.4	3.4
2003	0.5	0.0	0.0	0.8	0.4	3.2
2004	0.5	0.0	0.1	0.8	0.4	2.6
2005	0.5	0.0	0.0	0.8	0.4	2.1
2006	0.7	0.0	0.1	0.7	0.5	1.8
2007	0.7	0.0	0.1	0.7	0.6	1.8
2008	0.6	0.0	0.1	0.7	0.7	1.8
Trend 1990 - 2008	-	-91%	-10%	-21%	269%	-82%

Figure 2.6 shows the main sources of emissions in 2008.

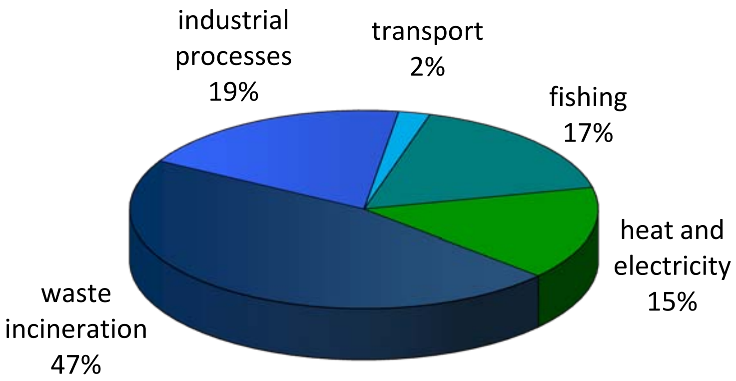

Figure 2.6. Emissions of dioxin by sector in 2008.

Practices of waste disposal treatment have undergone a radical change in Iceland since 1990. This is the main reason for the decline in emissions by 82% from 1990 to 2008. Open pit burning that used to be the most common means of waste disposal outside the capital area, has gradually decreased since 1990. At the same time total amount of waste being incinerated has decreased while increasing levels have been incinerated with energy recovery and thus reported under 1A1a and 1A4a. Waste incineration without energy recovery is non-existent today except from bonfires around New Year celebrations. A gradual decrease is seen in open pit burning since 1990 and from 2005 only bonfires are included in the Waste Incineration sector, along with emissions from one single incineration plant. In 2008 that incineration plant ceased operation.

Emissions from the electricity generation and space heating are very low because they are generated from renewable energy sources. Emissions in this sector are dominated by emissions from waste incineration with energy recovery.

From 1990 to 2008 emissions from road transport decreased by 91% despite the 81% growth in the number of vehicles. This is due to the phase-out of leaded fuel. Further emissions have decreased from the fishing sector as well as from the sector other transport due to less fuel consumption in these sectors. Emissions from fishing are high compared to the fuel consumption. The emission factors for burning fuel at sea are much higher than when burning fuel on land, due to the presence of salt (and therefore chlorine) in the air going to the engines.

Emissions from industrial processes have increased by 269% during the period due to increased activity in the non-ferrous metals production sector. Aluminium production has increased from 87.839 thousand tonnes in 1990 to 781.151 thousand tonnes in 2008 and production of ferrosilicon has increased from 62.792 thousand tonnes to 94.407 thousand tonnes in the same period. Emissions from industrial processes amount to 0.7 g I-TEQ and account for 19% of the total emissions.

Figure 2.7 to 2.10 show the emissions of dioxin within the EMEP-Grid in 1990, 1995, 2000 and 2005.

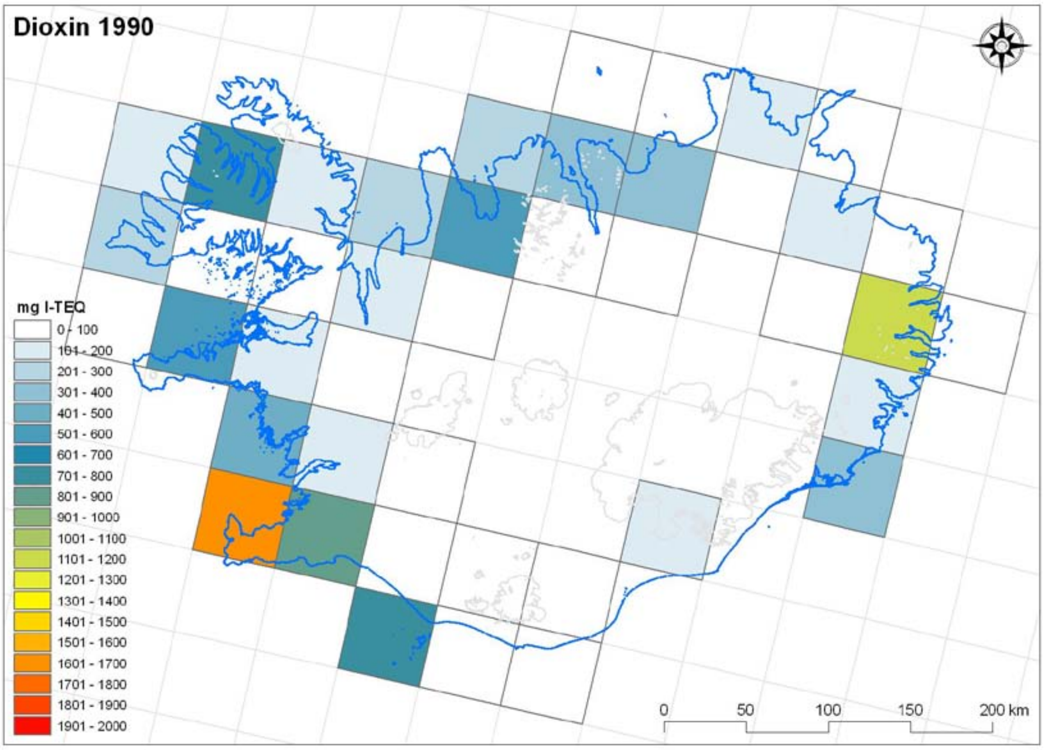

Figure 2.7. Emissions of dioxins within the EMEP-Grid in 1990.

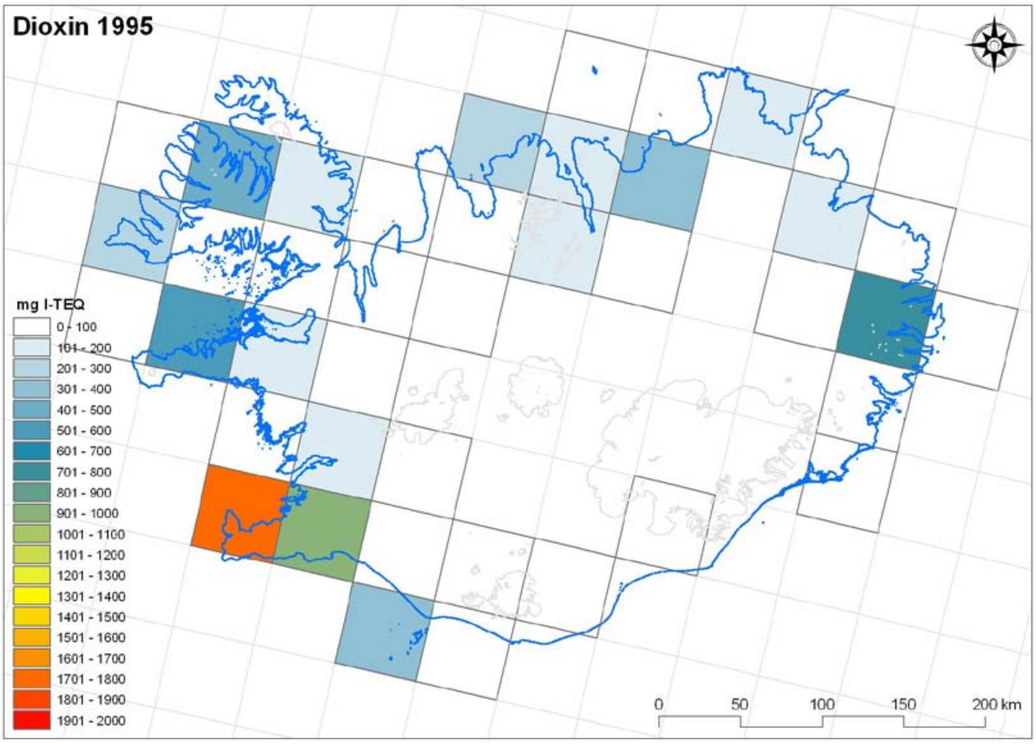

Figure 2.8. Emissions of dioxins within the EMEP-Grid in 1995.

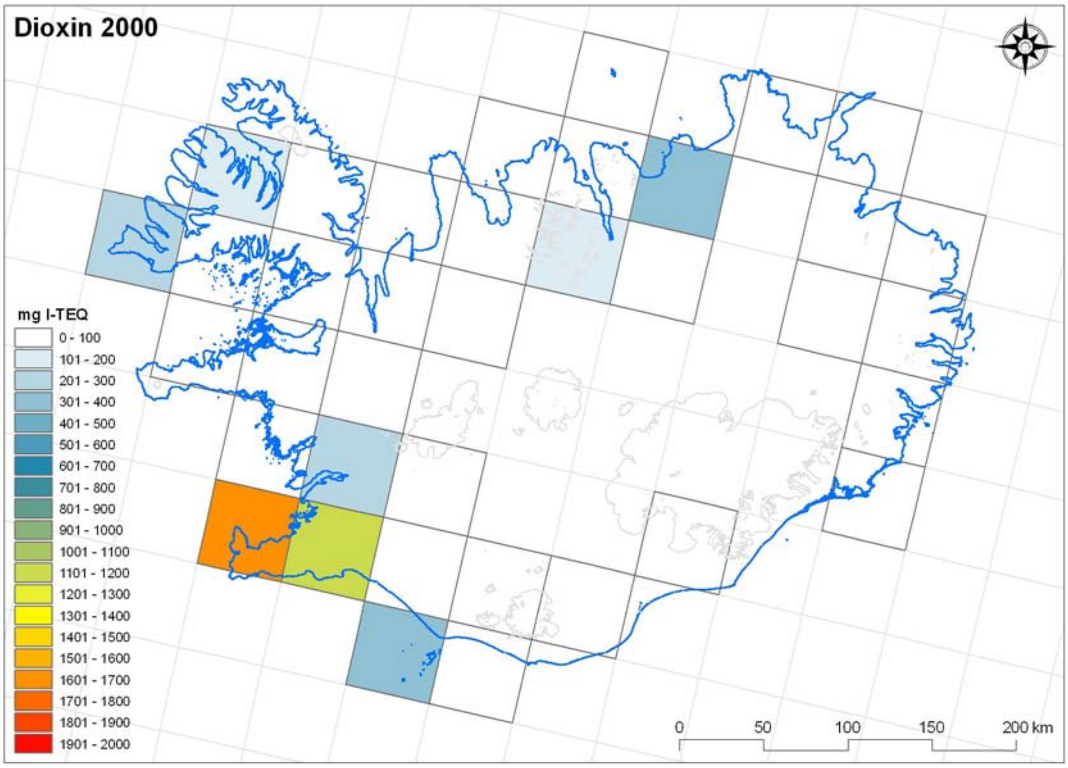

Figure 2.9. Emissions of dioxins within the EMEP-Grid in 2000.

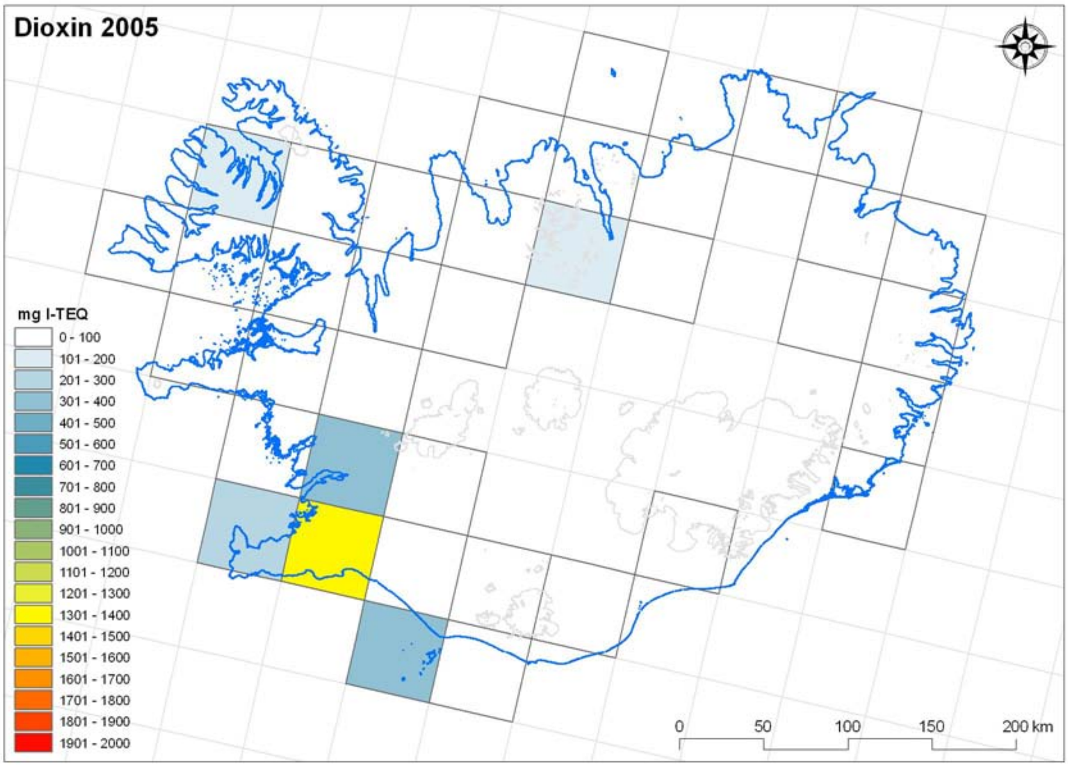

Figure 2.10. Emissions of dioxins within the EMEP-Grid in 2005.

2.4 Emission trends for NO_x, NMVOC, CO and SO_2

Nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) have an indirect effect on climate through their influence on greenhouse gases, especially ozone. Sulphur dioxide (SO_2) affects climate by increasing the level of aerosols that have in turn a cooling effect on the atmosphere. Iceland has only ratified the POP protocol of the CLRTAP. Reporting of other pollutants than POPs is therefore not obligatory. Emissions of the indirect greenhouse gases (NO_x, CO, NMVOC) and SO_2 are provided in the NFR tables for information purposes, as they are calculated to comply with the reporting requirements of the UNFCCC. A short description of the trends of those pollutants is given in the following section.

Nitrogen oxides (NOx)

The main sources of nitrogen oxides in Iceland are fishing, transport and the manufacturing industry and construction, as can be seen in Figure 2.11. The NO_x emissions from fishing rose from 1990 to 1996 when a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 emissions decreased, reaching the 1990 levels in 2001. Emissions in 2008 were 21% below the 1990 level. Annual changes are inherent to the nature of fisheries. Emissions from transport are dominated by road transport. These emissions have decreased rapidly (by 17%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 63%. The rise in emissions from the manufacturing industries and construction are dominated by increased activity in the construction sector during the period. Total NO_x emissions, like the emissions from fishing, increased until 1996 and decreased thereafter until 2001. Emission rose again between 2002 and 2004 and then decreased again. The emissions in 2008 were 14% below the 1990 level.

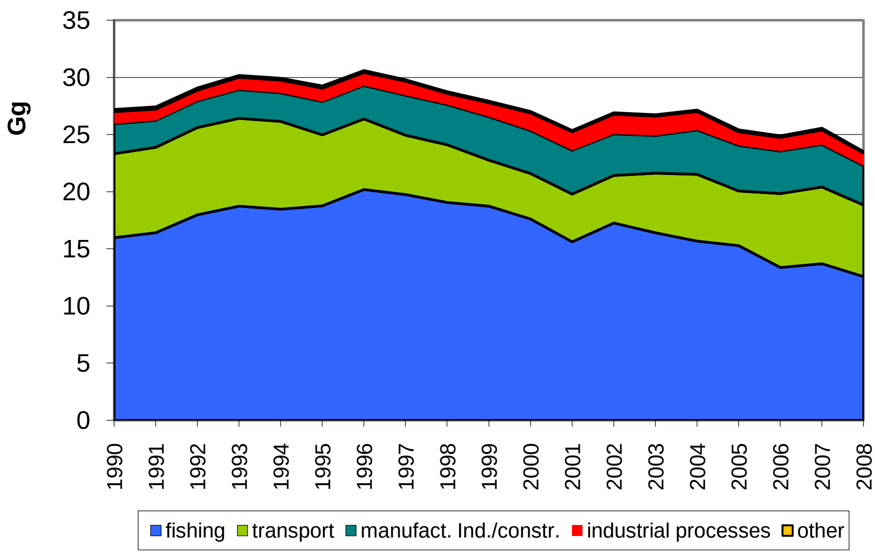

Figure 2.11. Emissions of NOx by sector 1990 – 2008, Gg.

Non-methane volatile organic compounds (NMVOC)

The main sources of non-methane volatile organic compounds are transport and solvent use, as can be seen in Figure 2.12. Emissions from transport are dominated by road transport. These emissions decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Emissions from solvent use have varied between 2 Gg and 4 Gg since 1990 with no obvious trend. The total emissions show a downward trend from 1994 to 2008. The emissions in 2008 were 55% below the 1990 level.

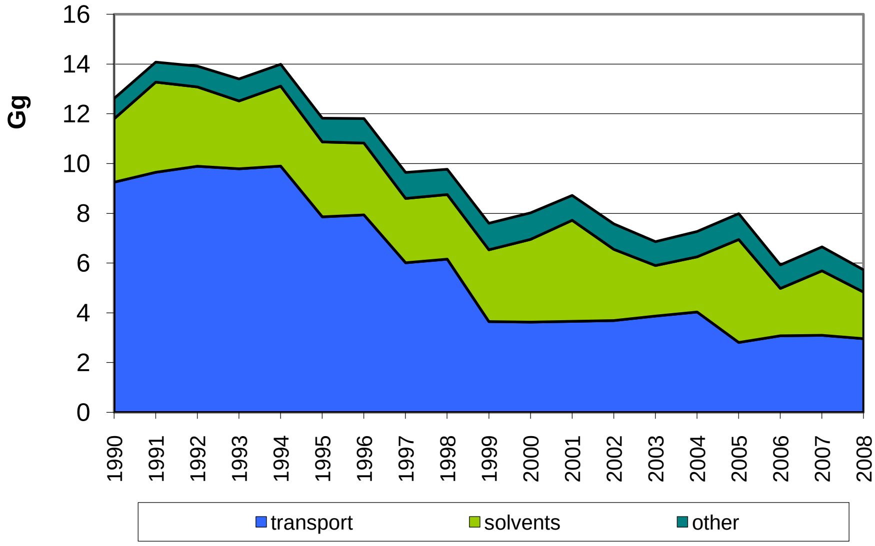

Figure 2.12. Emissions of NMVOC by sector 1990 – 2008, Gg.

Carbon monoxide (CO)

Transport is the most prominent contributor to CO emissions in Iceland, as can be seen in Figure 2.13. Emissions from transport are dominated by road transport. These emissions have decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Total CO emissions show, like the emissions from transport, a rapid decrease after 1990. The emissions in 2008 were 57% below the 1990 level.

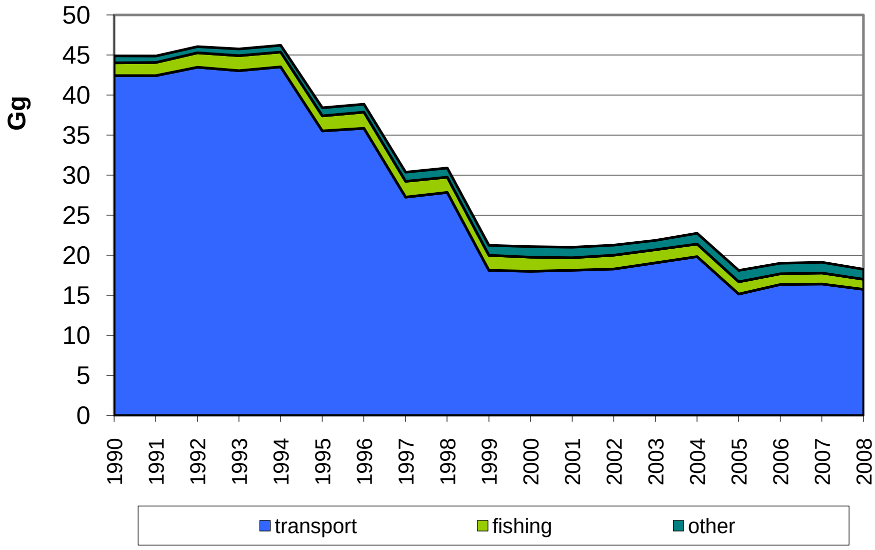

Figure 2.13. Emissions of CO by sector 1990 – 2008, Gg.

Sulphur dioxide (SO_2)

Geothermal energy exploitation is by far the largest source of sulphur emissions in Iceland. Sulphur emitted from geothermal power plants is in the form of H_2S. Emissions have increased by 370% since 1990 due to increased activity in this field. Other significant sources of sulphur dioxide in Iceland are industrial processes and manufacturing industry and construction, as can be seen in Figure 2.14. Emissions from industrial processes are dominated by metal production. Until 1996 industrial process sulphur dioxide emissions were relatively stable. Since then, the metal industry has expanded. In 1990, around 88,000 tonnes of aluminium were produced at one plant and around 63,000 tonnes of ferroalloys at one plant, Elkem Iceland. In 2008 around 781,151 tonnes of aluminium were produced at three plants and around 96,000 tonnes of ferroalloys were produced at Elkem Iceland. This led to increased emissions of sulphur dioxide. The fishmeal industry is the main contributor to sulphur dioxide emissions from fuel combustion in the sector Manufacturing industries and construction. Emissions from the fishmeal industry increased from 1990 to 1997 but have declined since; the emissions were 58% below the 1990 level in 2008.

In 2008 total sulphur emissions in Iceland, calculated as SO_2, were in 262% above the 1990 level.

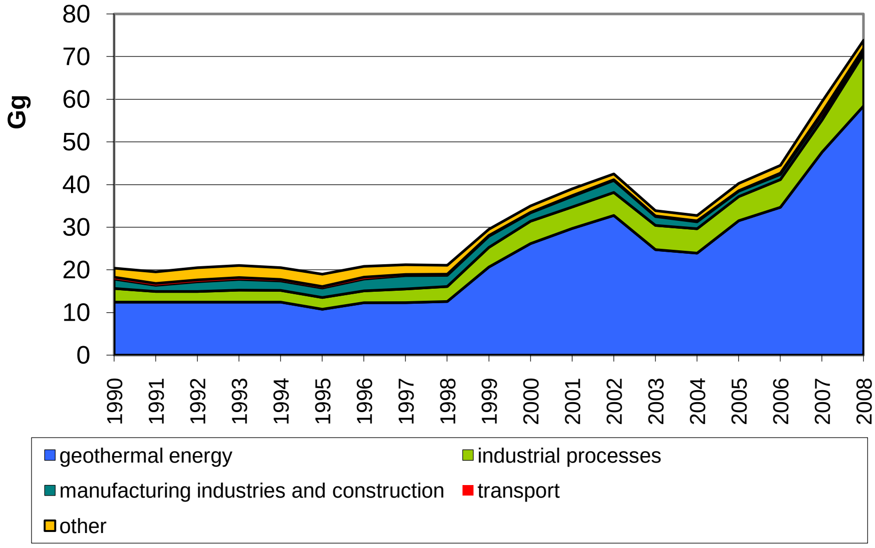

Figure 2.14. Emissions of SO_2 by sector 1990 – 2008, Gg.

3 METHODOLOGICAL ISSUES

3.1 Energy

The energy sector in Iceland is unique in many ways. Iceland ranks 1st among the OECD countries in the per capita consumption of primary energy. The consumption in 2008 was about 840 GJ. However, the proportion of domestic renewable energy in the total energy budget is nearly 80%, which is a much higher share than in most other countries. The cool climate and sparse population calls for high energy use for space heating and transport. Also key export industries such as fisheries and metal production are energy intensive. The metal industry used around 77% of the total electricity produced in Iceland in 2008. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (24.5% of the electricity) and on hydropower for electricity production (75.5% of the electricity). Thus, emissions in this sector originate predominantly from mobile sources: road transport, fishing and equipment in the construction sector, as well as waste incineration with energy recovery.

Activity data

Emissions from fuel combustion are estimated at the sectoral level. They are calculated by multiplying energy use by source and sector with pollutant specific emission factors. Activity data is provided by the National Energy Authority (NEA), which collects data from the oil companies on fuel sales by sector. Emissions from waste incineration with energy recovery are reported under 'energy industries' and 'commercial' but a description of the method is under the waste section.

Emission factors

Emission factors for dioxin from stationary combustion are taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2001) and from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). Emission factors for coal used in stationary combustion (used in the cement industry) as well as the profile ratio for the PAH4 are taken from the Emission Inventory Guidebook (EEA 2007). The BaP emission factor is found in Appendix 3 for industrial coal combustion for large plant. The emission factors are presented in Table 3.1.

Table 3.1. Emission factors for dioxin from stationary combustion

	dioxin [µg I-TEQ/t fuel]	BaP [mg BaP/t fuel]
Kerosene	0.1 [2]	NE
Gas / Diesel Oil	0.1[2]	NE
Residual fuel oil	0.1[2]	NE
Waste oil	4 [2]	NE
Light fuel oil fired power boilers	0.02 [1]	NE
Coal*	IE	0.14 [3]

[1] UNEP 2001, [2] Statistics Norway 2002, [3] EEA 2007
* coal is only used in the cement plant, all dioxin emissions are reported under 2A1

Emission factors for dioxin from mobile sources are taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2001) and from

Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). Emission factors for PAH for ocean going ships are taken from the Norwegian report Utslipp av noen miljögift i Norge (Statistics Norway 2001). All emission factors are presented in Table 3.2, except for the PAH emission factors used for calculating emissions from road transport and mobile equipment.

Table 3.2. Emission factors for dioxin and PAH4 from mobile combustion

	dioxin [µg I-TEQ/t fuel]	PAH [g PAH4/t fuel]
Jet Kerosene	0.06 [2]	NE
Aviation gasoline	2.2 [1]	NE
Gasoline, leaded	2.2 [1]	
Gasoline, unleaded, no catalyst	0.1[1]	
Gasoline, unleaded, with catalyst	0 [1]	
Gas / Diesel Oil, on land	0.1[1]	
Gas / Diesel Oil, on ocean	4 [2]	0.4 [2]
Residual fuel oil, on ocean	4 [2]	0.4 [2]

[1] UNEP 2001, [2] Statistic Norway 2002

The method for estimating PAH from road transport will be described in the next submission.

3.2 Industrial processes

The industrial process sector is important for emissions of both dioxins and PAH4, PAH4 from metal production in particular. Due to the expansion of energy intensive industry, emissions have increased rapidly since 1996. The main category within the industrial process sector is metal production. The location of operating industrial facilities in 2008 is shown in Figure 3.1.

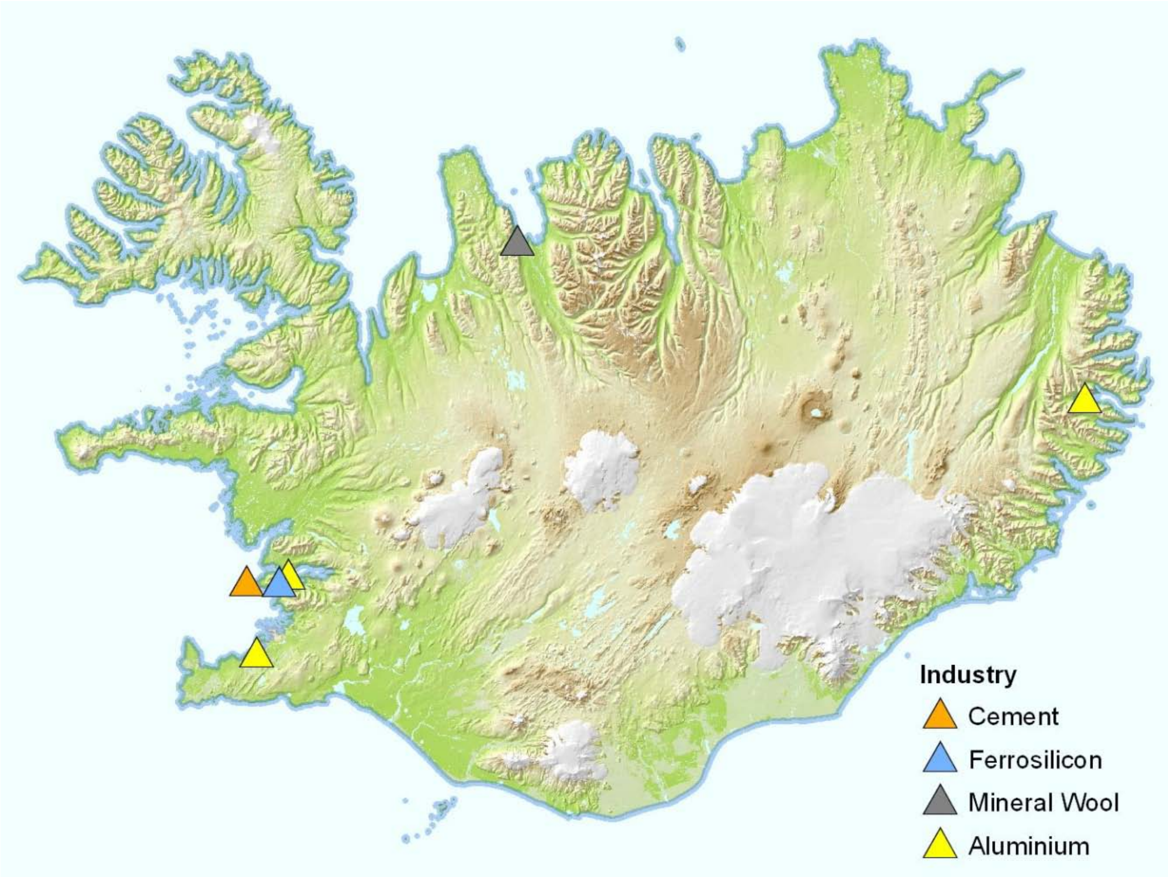

Figure 3.1. Location of industrial facilities in 2008.

3.2.1 Cement Production

The single operating cement plant in Iceland produces cement from shell sand and rhyolite in a rotary kiln using a wet process. The raw material calcium carbonate, which comes from shell sand, is calcinated in the production process. The resulting calcium oxide is heated to form clinker and then crushed to form cement.

Activity data

Process specific data on cement production, clinker production and amounts of coal are collected by the EA directly from the cement production plant.

Emission factors

Emission factor for dioxin is taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2001). The factor applies for wet kilns, with ESP/FF temperature < 200°C and is 0.15 µg I-TEQ/t cement. No process related PAH emissions are applicable for the cement industry.

3.2.2 Mineral Wool Production

Emissions of dioxins are calculated from the amount of electrodes used in the production process. The emission factor is taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002) and is 1.6 µg I-TEQ/t electrodes. PAH emissions are not estimated.

3.2.3 **Chemical industry**

The only chemical industry that has existed in Iceland is the production of silicium and fertilizer. The fertilizer production plant was closed down in 2001 and the silicium production plant was closed down in 2004. This industry is not considered to be a source of dioxins or PAHs.

3.2.4 **Metal Production**

Ferroalloys

Ferrosilicon (FeSi, 75% Si) is produced at one plant in Iceland. The raw material is quartz (SiO_2). The quartz is reduced to Si and CO using reducing agents. The waste gas CO and some SiO burns to form CO_2 and silicia dust. In the production raw ore, carbon material and slag forming materials are mixed and heated to high temperatures for reduction and smelting. The carbon materials used are coal, coke and wood. Electric (submerged) arc furnaces with Soederberg electrodes are used. The furnaces are semi-covered. Emissions originate from the use of coal and coke as reducing agent, as well as from consumption of electrodes.

Activity data

The consumption of reducing agents and electrodes are collected by the EA directly from the single operating ferroalloys production plant.

Emission factors

Emission factors for dioxin are taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). They are presented in Table 3.3. Emission factors for PAH were provided from the ferroalloys plant, assuming that about 45 to 50 kg of PAH4 are emitted per 120,000 t of produced ferrosilicon. The emission profile is taken from the Emission Inventory Guidebook (EEA 2007) for coal.

Table 3.3. Emission factors for dioxin from ferroalloys

	dioxin [µg I-TEQ/t fuel]
Coal	1.6 [2]
Coke	1.6 [2]
Waste wood	1[2]
Electrodes	1.6 [1]

[1] UNEP 2001, [2] Statistics Norway 2002

Aluminium Production

In 2008 aluminium was produced at 3 plants in Iceland. Best Available Technology (BAT) is used at all plants, i.e. closed prebake systems with point feeding of alumina, efficient process control, hoods covering the entire pot and efficient collection of air pollutants.

Primary aluminium production results in emissions of dioxins and PAH4. Emissions originate from the consumption of electrodes during the electrolysis process.

Activity data

The EA collects annual process specific data from the three operating aluminium plants.

Emission factors

The emission factor for dioxin stemming from the consumption of electrodes is the same as for the ferroalloys industry and is presented in Table 3.3. PAH4 emissions are calculated from measurements that were performed at one plant in 2002. According to the measurements, 18 g of PAH total per tonne aluminium go to the Air Pollution Control System. On average 10.6% of PAH total is PAH4. Of the total pot gases 98.5 % are collected and cleaned via dry adsorption unit. It is estimated that PAH4 is completely removed in that process. Thus, 1.5% of the pot gases leak unfiltered to the atmosphere, which means that emissions of PAH4 are 0.029 g/t aluminium. The emission profile is also taken from these measurements.

3.3 Solvent and other product use

Tobacco smoking is a minor source of dioxins and PAH. Dioxin emissions are calculated by multiplying the amount of imported tobacco with an emission factor. The emission factor of 0.1 ng/cigarette is taken from Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2001). Assuming that one cigarette contains 0.75 g of tobacco this gives an emission factor of 0.13 µg/t tobacco.

3.4 Waste

Activity data

Activity data on waste in Iceland has proven to have been insufficient in the past. There is little information about actual amounts of generated waste as well as on its composition and characteristics, before 1990. Activity data on incinerated waste from major incineration plants have been collected by the EA since 2000. Historic data as well as data on open pit burning not reported to EA, was estimated with the assumptions that 500 kg of wastes have been incinerated per inhabitant in the communities where waste is known to have been incinerated (both in primitive incineration plants as well as open pit burning) in 1990, 1995 and 2000 and interpolated in the years between. These communities were mapped by EA in the respective years. The data after the year 2000 is considered rather reliable, but pre-2000 data very unreliable. Figure 3.2 and Figure 3.3 show different waste management practices in 1990 and 2008.

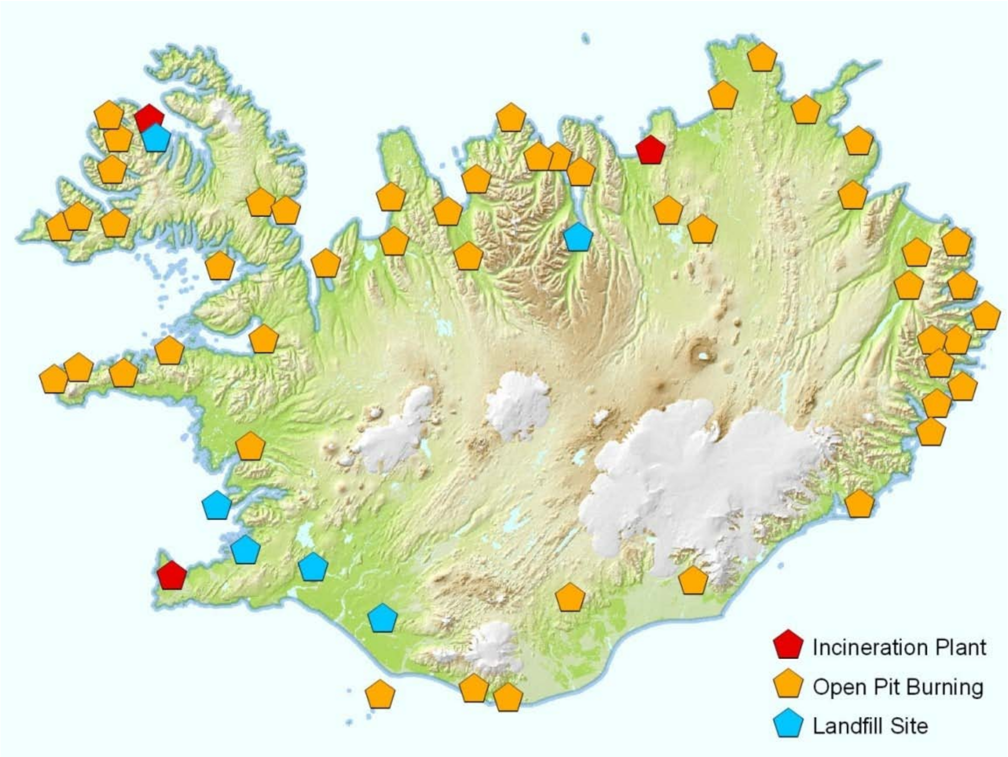

Figure 3.2. Waste management practices in 1990

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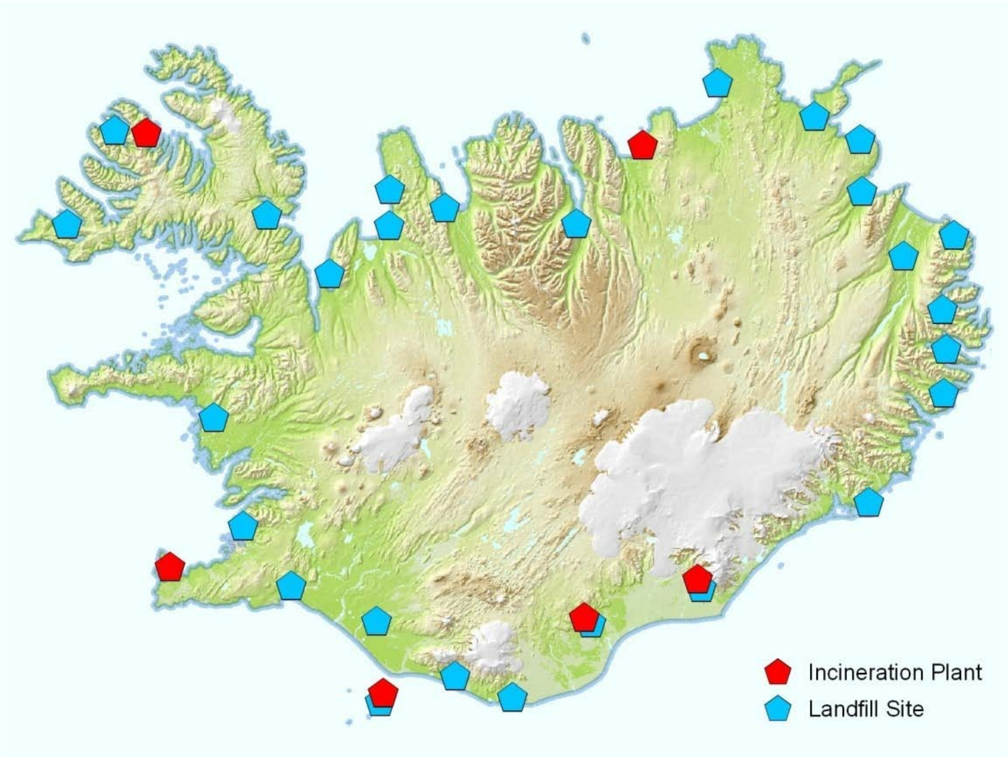

Figure 3.3. Waste management practices in 2008.

Emissions from waste incineration with energy recovery are reported in sector 1A1a (public electricity and heat production) and 1A4a (commercial). Amounts of incinerated wastes are presented in Table 3.4.

Table 3.4. Waste incineration from 1990 to 2008, thousand tonnes

Year	Incineration with energy recovery	incineration without energy recovery	bonfires
1990	-	33.8	4
1991	-	33.5	4
1992	-	32.6	4
1993	4.1	27.8	5
1994	4.1	25.6	5
1995	5.1	22.6	5
1996	6.5	20.2	5
1997	6.5	19.5	5
1998	6.5	16.5	6
1999	6.6	13.5	6
2000	6.6	12.7	6
2001	6.6	11.6	6
2002	6.6	10.8	6
2003	6.9	9.1	7
2004	16.6	4.3	7
2005	17.4	0.0	7
2006	22.8	0.0	6
2007	25.9	0.0	6
2008	22.4	0.0	6
Trend 1990 - 2008	-	-100%	50%

Emission factors

Emission factors for dioxin for waste incineration are taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2001). They represent two different kinds of incineration techniques. There are two other techniques used in Iceland. Several incineration plants from Hoval are used. Emission factor was calculated based on information from the producer. For one plant, taken into operation in 2006 reported values for dioxin are used in the emission inventory. Emission factors for PAH are taken from the Emission Inventory Guidebook (EEA 2007). They do not differentiate between different incineration techniques. The emission factors are presented in Table 3.5.

Table 3.5. Emission factors for dioxin and PAH from waste incineration

	dioxin [µg I-TEQ/t MSW]	BaP [mg BaP/t MSW]	BbF [mg BbF/t MSW]	BkF [mg BkF/t MSW]
Uncontrolled domestic waste burning	300 [1]	0.7	3.15	3.15
Hoval incineration plants	100 [2]	0.7	3.15	3.15
Controlled combustion, good APC	30 [1]	0.7	3.15	3.15
Kalka incineration plant	Reported [2]	0.7	3.15	3.15

[1] UNEP 2001, [2] plant specific

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