Emissions of Persistent Organic Pollutants and other air pollutants in Iceland 1990 - 2010

Informative Inventory Report 2012

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 tables) is Iceland's contribution to this round of reporting under the Convention, and covers emissions in the period 1990 – 2010. This report emphasizes on 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 and the calculation method of those pollutants are given in this report.

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

Environment Agency of Iceland, Reykjavík, July 2012

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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 (dioxins, polycyclic aromatic hydrocarbons and hexachlorbenzene) in the period 1990 – 2010. A description of the trend in emissions and calculation method of NO_x, NMVOC, CO and SO_2 is also given. Further estimates for SO_2, PM2.5 and PM10 for the volcano Eyjafjallajökull that erupted in 2010 are provided. Emissions of ammonia, heavy metals and particulate matter (other than from Eyjafjallajökull) have not been estimated.

Responsible institute

The Environment Agency of Iceland (EA), an agency under the auspices of the Ministry for the Environment is responsible for the annual preparation and submission of the Icelandic inventory to the Convention on Long-Range Transboundary Air Pollution. The EA participates in meetings under the UNECE Task Force on Emission Inventories and Projections and the related expert panels, where parties to the convention prepare the guidelines and methodologies on inventories.

Trends in emissions and removals

From 1990 to 2010 emissions of dioxins have decreased by 75% (Figure ES.1). The largest contributor of dioxin emissions in Iceland is waste incineration with and without energy recovery, followed by fishing.

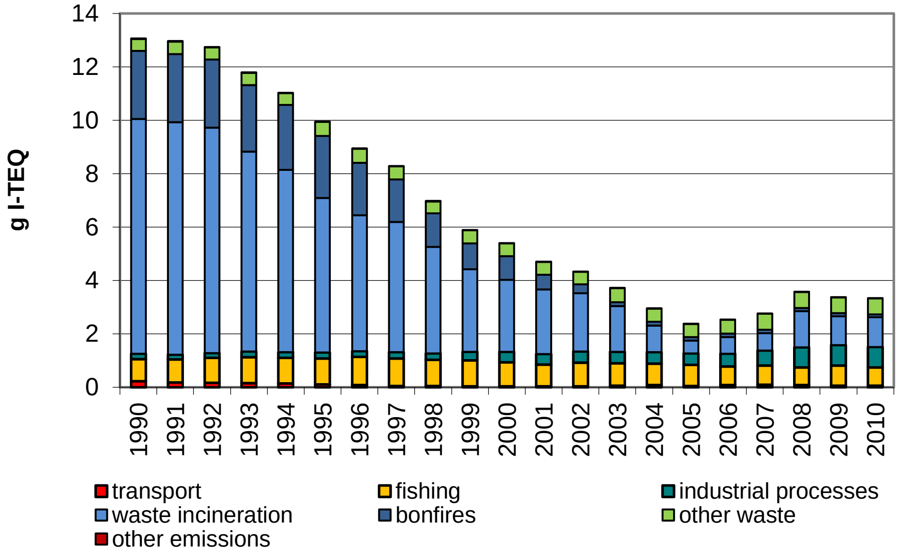

Figure ES.1 Trend in dioxins emissions from 1990 to 2010.

From 1990 to 2010 emissions of PAH4 have increased by 103% (Figure ES.2). The largest contributor of PAH4 emissions in Iceland are accidental fires (6D, waste) industrial processes and road transport.

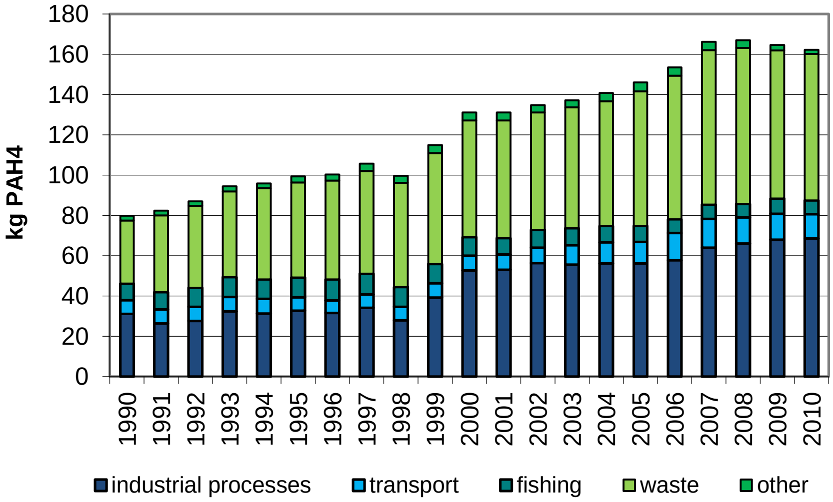

Figure ES.2 Trend in PAH4 emissions from 1990 to 2010.

From 1990 to 2010 emissions of HCB decreased by 36% (Figure ES.3). The largest contributor of HCB emissions in Iceland is waste incineration with and without energy recovery, followed by industrial processes. Emissions from waste incineration with energy recovery are reported under the Energy sector.

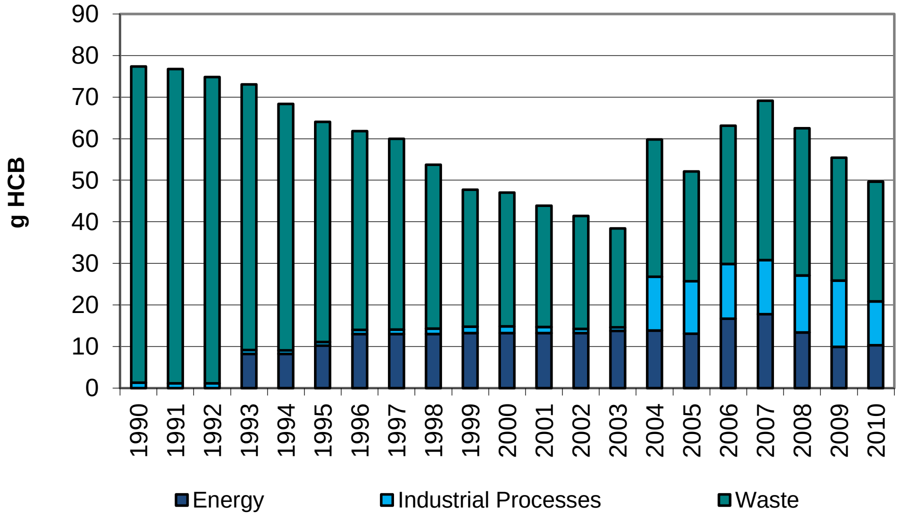

Figure ES.3 Trend in HCB emissions from 1990 to 2010.

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 Chapters 3 to 8 give information on methodologies used for emission calculations by sector. Chapter 9 contains information on gridded data.

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 dioxin/furans, PAH and HCB in the period 1990 – 2010, as well as gridded data for dioxin and PAH4 for the years 1990, 1995, 2000, 2005 and 2010. 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 and the calculation method of those pollutants are given in this report.

Since last submission several improvements have been made to the inventory. The main improvements are:

- Dioxin emissions estimates from waste incineration plants (with and without energy recovery) are partly based on measurements.
- Activity data and emission factors for dioxin from bonfires have been revised.
- Dioxin and PAH4 emissions from accidental fires, cremation and road paving with asphalt are now included.
- Dioxin emissions from secondary aluminium production are provided.
- HCB emissions have been estimated for several sources.
- Major revision has been done in the sector solvent and other product use.
- NMVOC emissions from the production of food and drink are estimated.
- The transparency has been greatly improved by providing more detailed description of the calculation methods.

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.

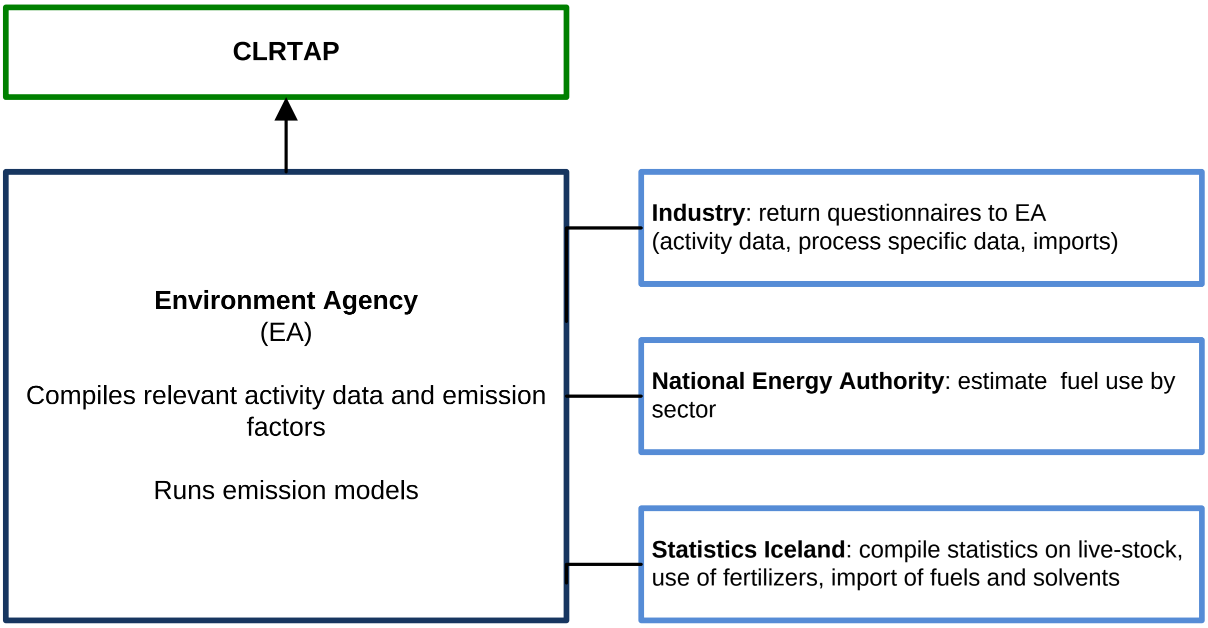

Figure 1.1 Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the CLRTAP

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. From 2008 and onwards, Act No. 48/2007, enables the NEA to obtain sales statistics from the oil companies. Statistics Iceland provides information on population, GDP, production of asphalt, food and beverages, imports of solvents and other products, the import of fertilizers 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, in accordance with Regulation no. 244/2009. Green Accounts submitted under Regulation no. 851/2002 from the industry are also used. EA also estimates activity data with regard to waste. Emission factors are mainly taken from the Emission Inventory Guidebook (EEA 2009, EEA 2007), the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005) 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. Dioxin was measured at several locations in Iceland in 2011, including waste incineration plants, aluminium plants and the ferrosilicon plant. The results from these measurements were used for waste incineration plants in this submission. Results from the measurements

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[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

at industrial sites were not available at the time of the submission of the data, but can hopefully be used by next submission.

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 (level assessment) is provided in Table 1.1.

Table 1.1 Key source analysis for reported pollutants

Component	Key Categories (sorted from high to low from left to right)							Total
Dioxin	1A1a 29.0%	1A4c iii 20.4%	6D 17.9%	2C3 16.6%				83.8%
PAH4	6D 44.7%	2C2 27.8%	2C3 14.5%					86.9%
HCB	6Cc 58.0%	2C3 20.5%	1A1a 19.3%					97.9%
SOx	1B2 79.7%	2C3 14.8%						94.5%
NOx	1A4c iii 60.1%	1A3b iii 10.0%	1A3b i 8.5%	1A2f ii 7.3%				86.0%
CO	1A3b i 51.2%	1A3b ii 18.5%	1A3b iii 10.4%					80.2%
NMVOC	1A3b i 35.8%	1A3b ii 11.8%	1A3b iii 8.3%	2D2 8.2%	1A4c iii 7.5%	3D2 6.4%	3A1 6.0%	84.0%

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 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://ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_manual.pdf. To further facilitate the QA/QC procedures all calculation sheets 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

In principle, the emissions inventory attempts to make estimates of all known emissions to air in as high a level of disaggregation as is possible. However, by following international guidelines on emissions reporting, there are some sources, which are deliberately not included in the national totals:

- Natural sources are not included in the national totals although estimates of some sources are made.
- Estimates of emissions from international navigation and aviation are made, and reported as memo items (excluded from national totals). For aviation this is not fully in line with the reporting guidelines for LRTAP, as cruise emissions from domestic and international aviation should be excluded from national totals, but emissions from landing and take-off from both domestic and international aviation should be included in national total. In the Icelandic inventory all emissions from domestic aviation are included in national totals but all emissions from international aviation are excluded (this is in line with the reporting guidelines under the UNFCCC).

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 of PAH4 and dioxins within the EMEP-Grid for the years 1990, 1995, 2000, 2005 and 2010.

In the case of temporal coverage, NFR table 1 is reported for the whole time series from 1990 to 2010, for dioxins and PAH4. HCB emissions have been estimated for few sources for the whole time series, but PCB emissions are not estimated. Further emissions of NO_x, CO, NMVOC and SO_2 are provided in the NFR table 1 for the same time period.

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 PAH4 are:

- 1A3b v: Road transport, gasoline evaporation
- 1A3b vi: Automobile tyre and break wear
- 1A3b vii: Automobile road abrasion
- 1A3d i: International maritime navigation
- 1A4a: Commercial/institutional
- 1A4b: Residential

The main sources not estimated for HCB are:

- 1A2: Manufacturing industry and construction
- 1A3: Transport
- 1A4b: Residential
- 1A4c iii: Fishing
- 2A6: Road paving with asphalt
- 2C2: Ferroalloys production
- 2F: Consumption of POPs and HM
- 3C: Solvent and other product use
- 6Cd: Cremation
- 6D: Other waste

2 TRENDS IN EMISSIONS

2.1 Emission profile in Iceland

The emissions profile for Iceland is unusual in some respects. First, emissions from generation of electricity and space heating are very low owing to the use of renewable energy sources. Almost all electricity in Iceland is produced with hydropower (74% in 2010) and geothermal power (26% in 2010). Furthermore geothermal energy sources are used for space heating (over 90% of all homes). It should be noted, though, that significant amounts of sulphur as hydrogen sulphide are emitted from geothermal power plants. Second, over 90% of the fuel used in the energy sector is for used by mobile sources (transport, mobile machinery and fishing vessels). Thirdly, emissions from industrial processes, especially from non-ferrous metal production, have higher share in Iceland than in most other countries. This can be seen in the fact that 79% of the electricity produced in Iceland in 2010 was used in the metal production industry. The production capacity has increased considerably since 1990. In 1990, 87.839 thousand tonnes of aluminium were produced in one aluminium plant, and 62.792 thousand tonnes of ferrosilicon in one ferrosilicon plant. In 1998 a second aluminium plant was established and a third one in 2007. In 1999 a third furnace was added to the ferrosilicon plant. In 2010 818.859 thousand tonnes of aluminium were produced at three aluminium plants and 102.214 thousand tonnes of ferrosilicon at the ferrosilicon plant. The emissions profile in Iceland is further influenced by the fact that Iceland was severely hit by an economic crisis late year 2008, when its three largest banks collapsed. The blow was particularly hard owing to the large size of the banking sector in relation to the overall economy as it had grown to be ten times the annual GDP. The crisis has resulted in serious contraction of the economy, a depreciation of the Icelandic króna (ISK), and a drastic increase in external debt. This has led to contraction in private consumption, rising fuel prices and collapse of the construction sector.

2.2 Trends in POPs emission

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.

The total amount of dioxins, PAH4 and HCB emitted in Iceland during the period 1990 – 2010 is presented in Table 2.1. It can be seen that emissions of PAH4 have increased by 103% from 1990 to 2010, whereas dioxin emission have decreased by 75% and HCB emissions by 36% during the same period.

Table 2.1. Emissions of POPs in Iceland 1990 – 2010.

Year	Emissions		
	Dioxin [g I-TEQ]	PAH4 [kg]	HCB [g]
1990	13.1	79.9	77.4
1991	13.0	82.3	76.7
1992	12.7	87.0	74.9
1993	11.8	94.4	73.1
1994	11.0	95.9	68.4
1995	9.9	99.4	64.0
1996	8.9	100.4	61.8
1997	8.3	105.7	60.0
1998	7.0	99.8	53.7
1999	5.9	114.9	47.7
2000	5.4	131.2	47.0
2001	4.7	131.2	43.9
2002	4.3	134.8	41.4
2003	3.7	137.1	38.4
2004	3.0	140.8	59.8
2005	2.4	146.1	52.1
2006	2.5	153.5	63.1
2007	2.8	166.1	69.1
2008	3.6	167.0	62.5
2009	3.4	164.5	55.4
2010	3.3	162.3	49.6
Trend 1990 – 2010	-75%	103%	-36%

2.2.1 Trends in dioxin emissions

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 13.1 g I-TEQ. In 2010 total emissions were 3.3 g I-TEQ. This implies a decrease of 75% over the time period. Table 2.2 shows the emissions by source from 1990 to 2010.

Table 2.2. Emissions of dioxin by sector 1990 – 2010, g I-TEQ.

Year	Energy industries and commercial	Road transport	Other transport	Fishing	Industrial processes	Waste
1990	0.0	0.1	0.1	0.8	0.2	11.8
1991	0.0	0.1	0.1	0.9	0.2	11.7
1992	0.0	0.1	0.1	0.9	0.2	11.4
1993	0.4	0.1	0.1	1.0	0.2	9.9
1994	0.4	0.1	0.1	1.0	0.2	9.2
1995	0.4	0.1	0.1	1.0	0.2	8.1
1996	0.4	0.0	0.1	1.0	0.2	7.1
1997	0.4	0.0	0.0	1.0	0.2	6.4
1998	0.4	0.0	0.0	1.0	0.2	5.3
1999	0.4	0.0	0.0	1.0	0.3	4.0
2000	0.4	0.0	0.0	0.9	0.4	3.5
2001	0.4	0.0	0.0	0.8	0.4	2.9
2002	0.4	0.0	0.0	0.9	0.4	2.4
2003	0.4	0.0	0.0	0.8	0.4	1.8
2004	0.4	0.0	0.1	0.8	0.4	1.1
2005	0.4	0.0	0.0	0.8	0.4	0.6
2006	0.5	0.0	0.1	0.7	0.5	0.7
2007	0.5	0.0	0.1	0.7	0.6	0.8
2008	1.2	0.0	0.1	0.7	0.7	0.8
2009	1.0	0.0	0.0	0.8	0.8	0.8
2010	1.0	0.0	0.0	0.7	0.8	0.8
Trend 1990 - 2010	-	-91%	-42%	-18%	281%	-93%

Figure 2.1 shows the main sources of emissions in 2010 and Figure 2.2 shows the percentage change in emissions by source categories from 1990 to 2010, compared to the 1990 level.

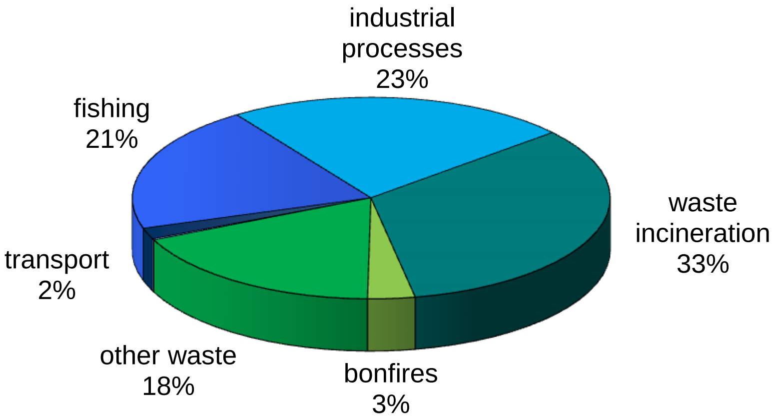

Figure 2.1. Emissions of dioxin by sector in 2010.

The main sources of dioxin emissions in 2010 are waste incineration with and without energy recovery (33%). Other important sources are industrial processes (23%), fishing (21%) and emissions from other waste (18%).

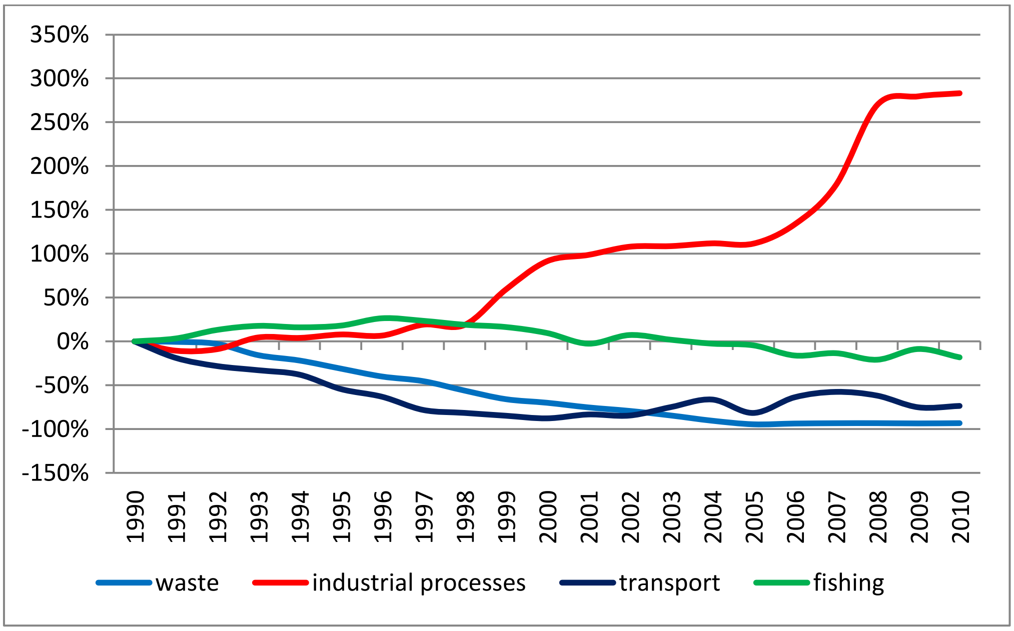

Figure 2.2. Percentage changes in emissions of dioxin by sector from 1990 to 2010, compared to 1990.

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 93% from 1990 to 2010. 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. Open pit burning is practically non-existent today, apart from one single site. In 2011 that incineration site was closed. Emissions from bonfires around New Year celebrations are included in the Waste Incineration sector.

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 2010 emissions from road transport decreased by 91% despite the 141% growth in the number of vehicles and 54% increase in fuel consumption. 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 281% 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 818.859 thousand tonnes in 2010, with the main increase after 2005. Production of ferrosilicon has increased from 62.792 thousand tonnes to 102.214 thousand tonnes in the same period. Emissions from industrial processes amount to 0.7 g I-TEQ and account for 23% of the total emissions.

2.2.2 **Trends in PAH emissions**

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 79.7 kg. In 2010 total emissions were 162.3 kg. This implies an increase of 103% over the time period. Table 2.3 shows the emissions by source from 1990 to 2010.

Table 2.3. Emissions of PAH4 by sector 1990 – 2010, kg.

Year	Energy industries and commercial	Manufacturing industry & construction	Road transport	Other transport	Fishing	Industrial processes	Waste
1990	-	2.4	6.1	0.8	8.3	31.1	31.2
1991	-	2.3	6.3	0.7	8.6	26.4	38.1
1992	-	2.2	6.4	0.7	9.4	27.6	40.7
1993	0.0	2.3	6.4	0.8	9.8	32.4	42.6
1994	0.0	2.4	6.5	0.7	9.6	31.4	45.2
1995	0.0	3.0	6.3	0.5	9.8	32.6	47.2
1996	0.1	2.9	5.7	0.6	10.5	31.6	49.1
1997	0.1	3.5	6.4	0.3	10.2	34.1	51.0
1998	0.1	3.5	6.4	0.3	9.9	27.9	51.7
1999	0.1	3.9	6.9	0.2	9.7	39.2	55.0
2000	0.1	4.0	7.3	0.2	9.1	52.7	58.0
2001	0.1	3.9	7.4	0.3	8.1	53.0	58.6
2002	0.1	3.6	7.5	0.2	8.9	56.3	58.1
2003	0.1	3.3	9.3	0.4	8.5	55.6	60.0
2004	0.1	4.0	9.9	0.6	8.1	56.2	61.9
2005	0.1	4.3	10.3	0.3	7.9	56.2	66.9
2006	0.1	3.9	12.7	0.6	7.0	57.9	71.3
2007	0.1	3.9	13.5	0.8	7.2	64.0	76.6
2008	0.1	3.8	12.4	0.7	6.6	66.0	79.5
2009	0.1	2.6	12.5	0.4	7.6	68.0	73.5
2010	0.1	2.1	11.7	0.4	6.8	68.5	72.7
Trend 1990 – 2010	-	-15%	93%	-41%	-18%	120%	133%

Figure 2.3 shows the main sources of emissions in 2010 and Figure 2.4 shows the percentage change in emissions by source categories from 1990 to 2010, compared to the 1990 level.

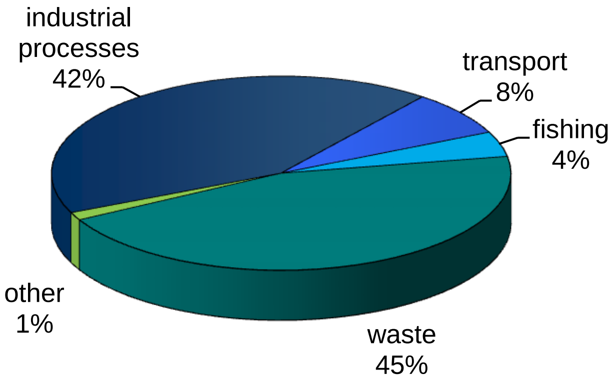

Figure 2.3. Emissions of PAH4 by sector in 2010.

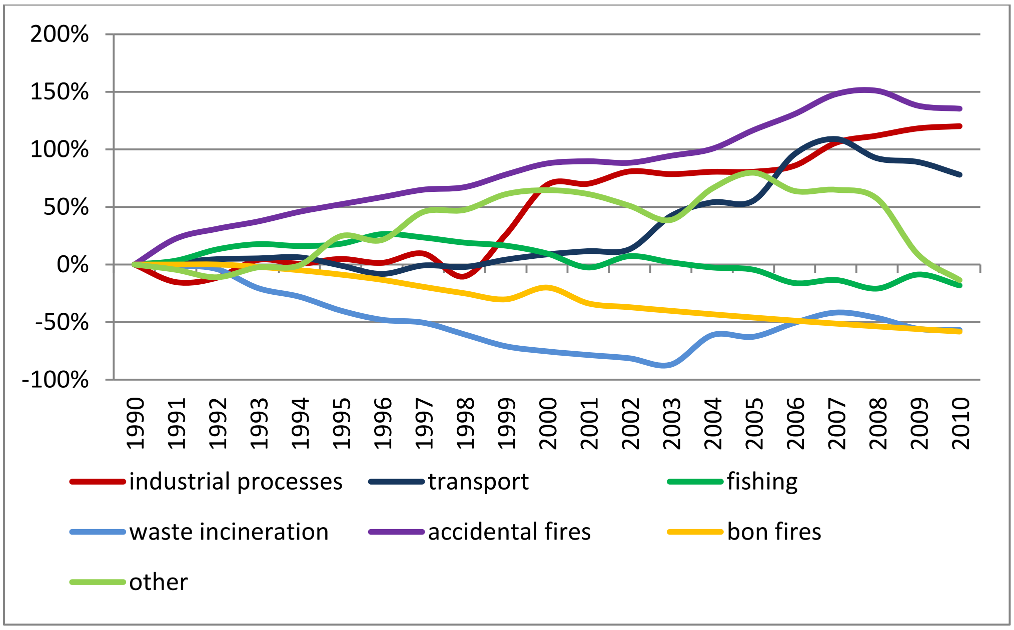

Figure 2.4. Percentage changes in emissions of PAH4 by sector from 1990 to 2010, compared to 1990.

The main reason for the growth in emissions from 1990 to 2010 can be explained by increased emissions from accidental fires on one hand and increased production capacity in the non-ferrous metals production sector on the other hand.

Accidental vehicle fires have increased with increasing vehicle fleet, which has increased by 141% since 1990. Emissions from accidental building fires have increased with increased population, which has grown by 25% from 1990 to 2010. The knock-off effect of the increased levels of economic growth until 2007 was an increase in construction, especially house building in the capital area.

As stated above, the production capacity in the metal production sector has increased substantially. Aluminium production has increased from 87.839 thousand tonnes in 1990 to 818.859 thousand tonnes in 2010 and from ferrosilicon production has increased from 62.792 thousand tonnes in 1990 to 102.214 thousand tonnes in 2010. A dip in PAH4 emissions from industrial processes are observed in 1998. Unusual weather conditions during the winter of 1997/1998 led to unfavourable water conditions for the hydropower plants operated in Iceland. This led to a power shortage, which caused a temporary closure of the ferrosilicon plant. In 1999 the plant was extended by the third furnace. The highest rise in emissions can be seen in the years 1999 and 2000, after the third furnace came into full operation. A smaller rise in emissions can be seen from 2006 due to the increased production capacity in the aluminium 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 crisis when its 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. Emissions from the construction sector were 48% lower in 2010 than in 2007 and emissions from the cement plant were 84% lower.

Road transport is an important source of PAH4 emissions in Iceland. Since 1990 the vehicle fleet in Iceland has increased nearly by 141%. Furthermore the trend until 2007 was towards larger passenger cars which consume more fuel. In recent years the share of diesel cars has also increased substantially. This led to increased emissions from road transportation. Emissions from road transport in 2007 were 122% higher than in 1990. In 2008 fuel prices rose significantly leading to lower emissions from the sector compared to the year before. PAH4 emissions from road transport in 2010 were 13% below the 2007 level, but 93% above the 1990 emissions.

Emissions from mobile sources in the construction industry are also of some importance. Emissions from the construction sector have risen, particularly in the years 2002 to 2007, 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). In 2007 the emissions were 62% above the 1990 level. As mentioned before the construction sector collapsed in 2008. Emissions from construction were 15% lower in 2010 than in 1990, and have declined by 48% since 2007.

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 2010, the emissions were 18% below 1990 levels. Annual changes in emissions reflect the inherent nature of the fishing industry.

Emissions from the waste incineration have decreased by 82% from 1990 to 2010, 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 sector.

2.2.3 Trends in HCB emissions

Hexachlorobenzene (HCB) or perchlorobenzene is a chlorocarbon with the molecular formula C_6Cl_6. HCB is a fungicide that was first introduced in 1945 for seed treatment, especially for control of bunt of wheat. HCB is currently emitted as a by-product in the manufacture of several chlorinated solvents. On the whole, processes resulting in dioxin formation also result in HCB emissions. HCB is considered to be probable human cancerogen. HCB is a very persistent environmental chemical due to its chemical stability and resistance to biodegradation. Analysis of trends in HCB emissions in Iceland must be interpreted with care as only few sources have been estimated. In 1990, the total emissions of HCB in Iceland were 77.4 g. In 2010 total emissions were 49.6 g. This implies a decrease of 36% over the time period.

Table 2.4 shows the emissions by source from 1990 to 2010. Figure 2.5 shows the main sources of emissions in 2010.

Table 2.4. Emissions of HCB by sector 1990 – 2010, g.

Year	Energy industries and commercial	Industrial processes	Waste
1990	-	1.3	76.1
1991	-	1.2	75.6
1992	-	1.1	73.8
1993	8.2	1.0	63.9
1994	8.2	0.9	59.3
1995	10.2	0.9	52.9
1996	13.0	1.0	47.8
1997	13.0	1.1	45.9
1998	13.3	1.3	39.4
1999	13.3	1.5	33.0
2000	13.3	1.6	32.2
2001	13.3	1.4	29.2
2002	13.3	0.9	27.2
2003	13.8	0.8	23.7
2004	13.9	12.9	33.0
2005	13.1	12.6	26.4
2006	16.7	13.2	33.3
2007	17.8	13.0	38.3
2008	13.4	13.7	35.4
2009	9.9	15.9	29.6
2010	10.3	10.6	28.8
Trend 1990 – 2010	-	741%	-62%

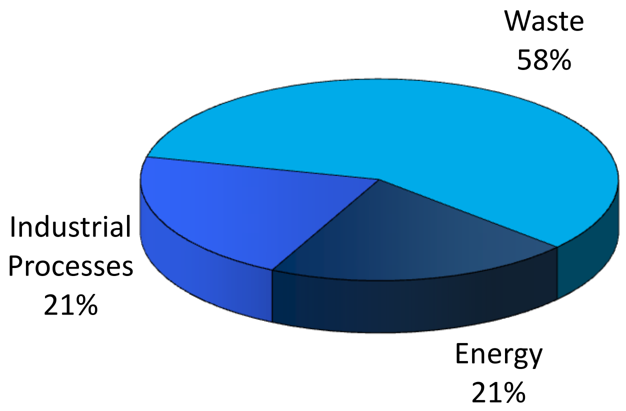

Figure 2.5. Emissions of HCB by sector in 2010.

The main sources of HCB emissions are waste incineration with and without energy recovery and industrial processes (secondary aluminium production and cement production). A sudden increase in HCB emissions from industrial processes is seen in 2004 when a secondary aluminium production plant was established.

2.3 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 adverse effect on human health and the environment. Iceland has only ratified the POP protocol of the CLRTAP. Reporting of other pollutants than POPs is therefore not obligatory. Emissions of 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.

2.3.1 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 2.6. 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 rose again in 2002 but have declined since with exception of 2009 due to less fuel consumption. Emissions in 2010 were 19% 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 20%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 54%. The rise in emissions from the manufacturing industries and construction until 2007 are dominated by increased activity in the construction sector during the period. In 2010 emissions from manufacturing industry and construction were

29% lower than in 1990. This is due to the collapse of the construction sector (including less emission from the cement plant) and to less fuel consumption at fishmeal plants as fuel has been replaced with electricity and production has decreased. Total NO_x emissions, like the emissions from fishing, increased until 1996 and decreased thereafter until 2001. Emission rose again between 2001 and 2004 and then decreased again. Total NO_x emissions in 2010 were 21% below the 1990 level.

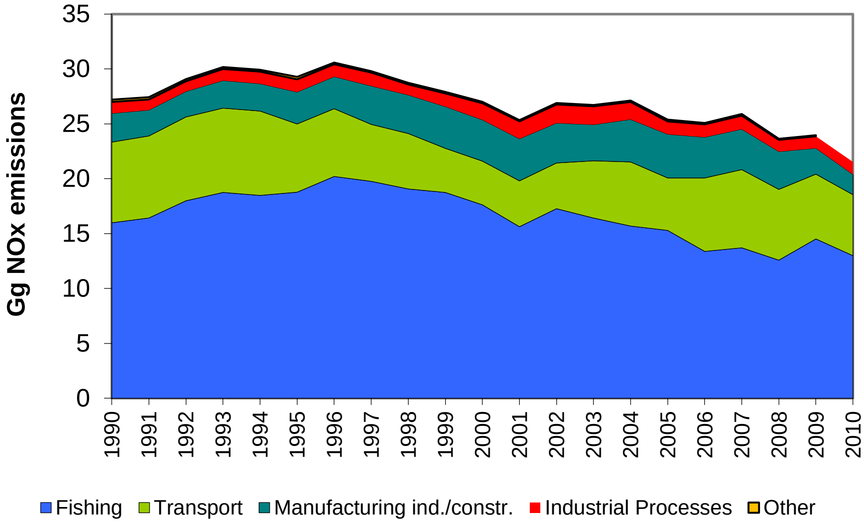

Figure 2.6. Emissions of NOx by sector 1990 – 2010, Gg.

2.3.2 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 2.7. 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 been around 1 Gg and show a downward trend in recent years. Other emissions include emissions from industrial processes, where food and drink production is the most prominent contributor. The total emissions showed a downward trend from 1994 to 2010. The emissions in 2010 were 57% below the 1990 level.

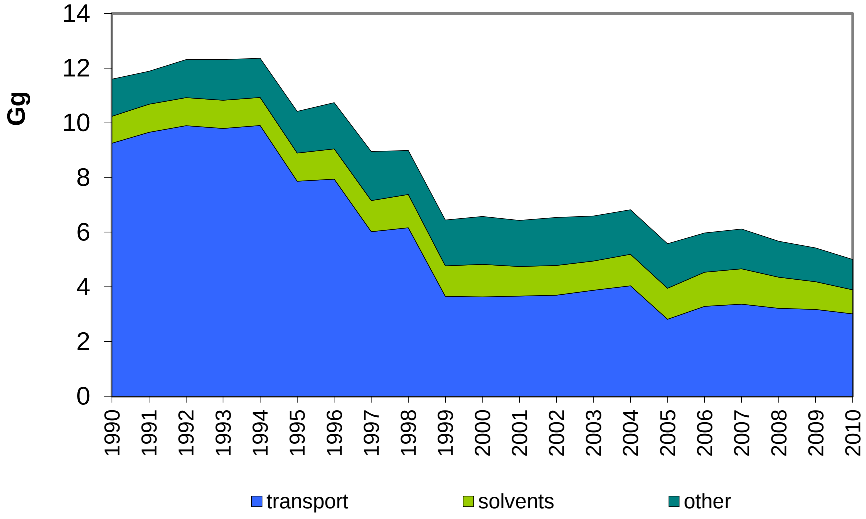

Figure 2.7. Emissions of NMVOC by sector 1990 – 2010, Gg.

2.3.3 Carbon monoxide (CO)

Transport is the most prominent contributor to CO emissions in Iceland, as can be seen in Figure 2.8. 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 2010 were 59% below the 1990 level.

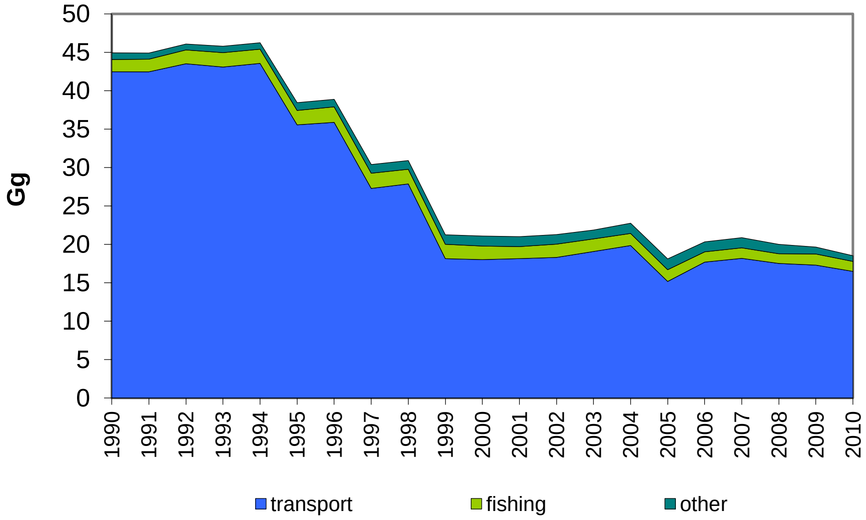

Figure 2.8. Emissions of CO by sector 1990 – 2010, Gg.

2.3.4 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 333% since 1990 due to increased activity in this field, as electricity production at geothermal power plants has increased 15-fold since 1990. The expansion of the metal production sector has been accommodated with parallel investments in increased power capacity, especially after 2005. Other significant sources of sulphur dioxide in Iceland are industrial processes and manufacturing industry and construction, as can be seen in Figure 2.9. 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, 88,839 tonnes of aluminium were produced at one plant and 62,792 tonnes of ferroalloys at one plant. In 2010 818,859 tonnes of aluminium were produced at three plants and 102,214 tonnes of ferroalloys were produced at one plant. This led to increased emissions of sulphur dioxide (238% increases from 1990 levels). 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 as fuel has been replaced with electricity and production has decreased; the emissions were 69% below the 1990 level in 2010.

Sulphur emissions from the fishing fleet depend upon the use of residual fuel oil. When fuel prices go up, the use of residual fuel oil rises and the use of gas oil drops. This leads to higher sulphur emissions as the sulphur content of residual fuel oil is significantly higher than in gas oil. The rising fuel prices since 2008 have led to higher sulphur emissions from the fishing fleet in recent years. Emissions from the fishing fleet in 2010 were 7% above the 1990 level although fuel consumption was 19% less.

In 2010 total sulphur emissions in Iceland, calculated as SO_2, were in 241% above the 1990 level, but 87% above the 1990 level when excluding emissions from geothermal power plants.

In 2010 the volcano Eyjafjallajökull started eruption. The eruption lasted from 14th of April until 23rd of May. During that time 127 Gg of SO_2 were emitted or 75% more than total man made emissions in 2010. These emissions are not included in national totals.

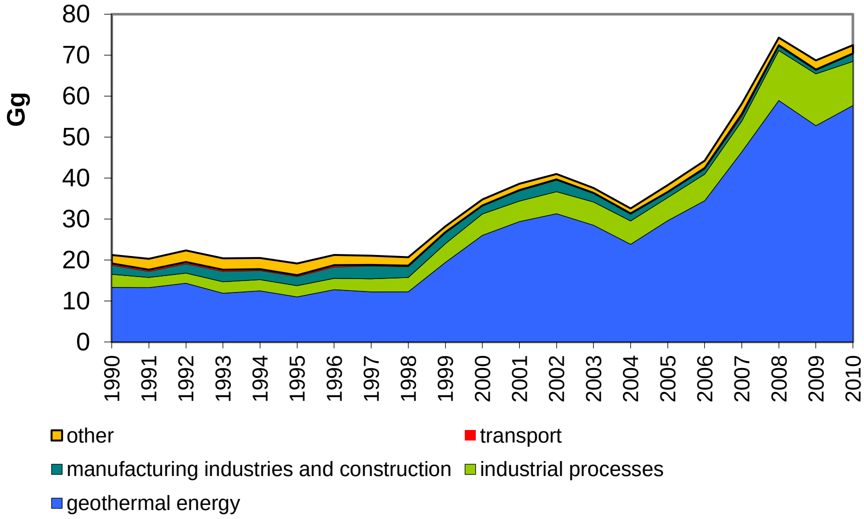

Figure 2.9. Emissions of SO_2 by sector 1990 – 2010, Gg.

3 ENERGY

3.1 Introduction

The Energy sector in Iceland is unique in many ways. Iceland ranks 1st among OECD countries in the per capita consumption of primary energy. The per capita primary energy consumption in 2010 was about 753 GJ. However, the proportion of domestic renewable energy in the total energy budget is about 85%, 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 production industry used around 79% of the total electricity produced in Iceland in 2010. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (26% of the electricity) and on hydropower for electricity production (74% 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.

Recalculations have been made in the Energy sector since last submission by reason of fuel allocation in the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary) and 1A4 Residential. Further two waste incineration facilities which were covered by the Energy sector in earlier submissions are now covered by the Waste sector.

Methodology

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. The division of fuel sales by sector does not reflect the IPCC/NFR sectors perfectly so EA has made adjustments to the data where needed to better reflect the IPCC/NFR categories. Further explanation of this adjustment is given in Annex I. This applies for the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary combustion) and 1A4 Residential. 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. Fuel combustion activities are divided into two main categories; stationary and mobile combustion. Stationary combustion includes Energy Industries, Manufacturing Industries and a part of the Other sectors (Residential and Commercial/Institutional sector). Mobile combustion includes Civil Aviation, Road Transport, Navigation, Fishing (part of the Other sectors), Mobile Combustion in Construction (part of Manufacturing Industries and Construction sector) and International Bunkers.

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, estimating uncertainties, archiving information and reporting, as further elaborated in the QA/QC manual. No source specific QA/QC procedures have been developed yet for the Energy sector.

3.2 Energy Industries (1A1)

Energy Industries include emissions from electricity and heat production. Iceland has extensively utilised renewable energy sources for electricity and heat production, thus emissions from this sector are low. For dioxin, PAH4, SO_2 and NMVOC waste incineration with energy recovery is the main source of emissions for this category. Activity data on fuel use for the energy industries are based on data provided by the NEA and adjusted by EA, see Annex I. Activity data on waste is collected by EA directly from the plants.

Electricity

Electricity was produced from hydropower, geothermal energy and fuel combustion in 2010 (Table 3.1.), with hydropower as the main source of electricity (NEA, 2011). Electricity was produced with fuel combustion at a two locations that are located far from the distribution system (two sparsely populated islands, Grimsey and Flatey). Some public electricity facilities have emergency backup fuel combustion power plants which they can use when problems occur in the distribution system. Those plants are however very seldom used, apart from testing and during maintenance.

Table 3.1. Electricity production in Iceland (GWh).

	1990	1995	2000	2005	2007	2008	2009	2010
Hydropower	4,159	4,678	6,352	7,014	8,394	12,427	12,279	12,592
Geothermal	283	288	1,323	1,658	3,579	4,037	4,553	4,465
Fuel combustion	5.6	8.4	4.4	7.8	3.5	2.7	2.9	1.7
Total	**4,447**	**4,977**	**7,679**	**8,680**	**11,976**	**16,467**	**16,835**	**17,059**

Activity data (the amount of gasoil used) for electricity production with fuel combustion is calculated from the information on electricity production (GWh), based on the energy content of the gasoil (43.33 TJ/kt) assuming 34% efficiency.

Heat

Geothermal energy was the main source of heat production in 2010. Some district heating facilities, which lack access to geothermal energy sources, use electric boilers to produce heat from electricity. They depend on curtailable energy. These heat plants have back up fuel combustion in case of electricity shortages or problems in the distribution system. Two district heating facilities burn waste to produce heat and are connected to the local distribution system. Emissions from these waste incineration plants are reported under Energy Industries. A description of the method to estimate emissions from waste incineration plants is given in Chapter 7.

Activity data for electricity and heat production with fuel combustion and waste incineration are given in Table 3.2. No fuel consumption for heat production was reported by the NEA for 2010. The use of residual fuel oil in 2007 was much higher than in surrounding years. In 2007 a new aluminium plant was established in Iceland. Because the Kárahnjúkar hydropower project (hydropower plant built for this aluminium plant) was delayed, the aluminium plant was supplied for a while with electricity from the distribution system. This led to electricity shortages for the district heating system and industry depending on curtailable energy leading to increased fuel combustion. The different fuel composition from year to year (waste, fuel) effect the IEF. For example the IEF for dioxin in this sector is higher in years when fuel combustion is low and the sector is dominated by waste incineration. Unusual years have been 1995 (issues in the electricity distribution system caused by snow avalanches in northwest Iceland (the Westfjords) and icing in the northern part of the country), 1997/1998 (see section 2.2.2) and 2007 (explained above).

Table 3.2. Fuel combustion and waste incineration (kt) for electricity and heat production.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil (electricity)	1.4	2.1	1.1	1.9	0.8	0.7	0.7	0.4
Residual fuel oil (heat)	3.0	3.1	0.1	0.2	4.5	0.1	0.1	-
Solid waste (heat)	NO	4.7	6.0	6.0	8.2	6.3	4.7	4.8

Emission factors for dioxin are taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005). They are 0.5 µg I-TEQ/TJ (0.022 µg I-TEQ/t fuel) for gas/diesel oil and 2.5 µg I-TEQ/TJ (0.1 µg I-TEQ/t fuel) for residual fuel oil. PAH4 and HCB emissions are not estimated from this source. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for NOx and CO are taken from Table 1-15 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. NMVOC emission factor is taken from Table 1.11 in the Reference Manual.

3.3 Manufacturing Industries and Construction (1A2)

3.3.1 Manufacturing Industries, Stationary Combustion

Activity Data

Information about the total amount of fuel used by the manufacturing industries was obtained from the National Energy Authority and adjusted by EA (see Annex I). The total fuel consumption per fuel type can be seen in Table 3.3. The sales statistics for the manufacturing industry (as adjusted by EA) are given for the sector as a total. They do not specify the fuel consumption by the different industrial sources. This division is made by EA on basis of the reported fuel use by all major industrial plants falling under law no. 65/2007 (metal production, cement) and from green accounts submitted by the industry in accordance with regulation 851/2002 for industry not falling under law no. 65/2007. There is thus a given total, which the usage in the different sectors must sum up to. Fuel consumption in the fishmeal industry from 1990 to 2002 was estimated from production statistics, but the numbers for 2003 to 2010 are based on data provided by the industry (Green Accounts submitted under regulation 851/2007). The difference between the given total for the sector and the sum of the fuel use of the reporting industrial facilities are categorized as 1A2f other non-specified industry. Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Emissions from fuel use in the ferroalloys production is reported under 1A2a. Emissions from the cement industry and the mineral wool production are reported under 1A2fi. For PAH4, emissions from the mineral wool production are not estimated, and for dioxin, emissions from the cement industry are reported under industrial processes (2A1).

Table 3.3. Fuel use (kt), stationary combustion in the manufacturing industry.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	5.1	1.1	10.3	22.2	14.9	8.6	9.8	9.4
Residual fuel oil	55.9	56.2	46.2	25.0	22.8	20.5	17.6	16.5
LPG	0.5	0.4	0.9	0.9	1.5	1.9	1.2	1.0
Electrodes (residue)	0.8	0.3	1.5	-	0.5	0.5	0.4	0.4
Steam Coal	18.6	8.6	13.3	9.9	24.4	21.5	10.2	3.6
Petroleum coke	-	-	-	8.1	0.2	-	-	-
Waste oil	-	5.0	6.0	1.8	2.3	2.2	0.9	1.4

Emission factors

Emission factors for dioxin for liquid fuel used in stationary combustion in manufacturing industry are taken from the Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). PAH4 emission factors for coal used in stationary combustion (used in the cement industry) as well as the profile ratio are taken from the chapter An approach to estimation of PAH emission in the Emission Inventory Guidebook (EEA 2007). The BaP emission factor for industrial coal combustion for large plant is taken from Appendix 3 of the chapter and the profile ratio is found in section 7. PAH emission factors for liquid fuels are taken from table 3-4 (Tier 1 EF for 1A2 combustion in industry using liquid fuels) from Chapter 1.A.2 of the Emission Inventory Guidebook (EEA 2009). The emission factors for dioxin and PAH4 are presented in Table 3.4.

Table 3.4. Emission factors for dioxin and PAH4 from stationary combustion in manufacturing industry

	dioxin [µg I-TEQ/t fuel]	BaP [µg/GJ]	BbF [µg/GJ]	BkF [µg/GJ]	IPy [µg/GJ]
Gas / Diesel Oil	0.1	5.2	6.2	4.0	2.2
Residual fuel oil	0.1	5.2	6.2	4.0	2.2
LPG	0.06	5.2	6.2	4.0	2.2
Electrodes residues	IE*	0.14	PR: 0.05	PR: 0.01	PR: 0.8
Steam Coal	IE*	0.14	PR: 0.05	PR: 0.01	PR: 0.8
Petroleum coke	IE*	5.2	6.2	4.0	2.2
Waste oil	4.0	5.2	6.2	4.0	2.2

* Coal, electrodes residues and petroleum coke are only used in the cement plant; all dioxin emissions from the cement plant are reported under 2A1
PR: profile ratio

SO_2 emissions are calculated from the S-content of the fuels. Source specific emission factors for NOx and CO are taken from Table 1.16 and 1.17 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Emission factors for NMVOC are taken from Table 1.11 in the Reference Manual. Sulphur emissions from use of petroleum coke occur in the cement industry. Further waste oil has mainly been used in the cement industry. Emission estimates for SO_2 for the cement industry are based on measurements.

3.3.2 Manufacturing Industries, Mobile Combustion

Activity Data

Activity data for mobile combustion in the construction sector is provided by the NEA. Oil, which is reported to fall under vehicle usage, is in some instances actually used for machinery and vice versa as it happens that machinery tanks its fuel at a tank station, (thereby reported as road transport), as well as it happens that fuel that is sold to contractors, to be used on machinery, is used for road transport (but reported under construction). This is, however, very minimal and the deviation is believed to level out. Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Activity data for fuel combustion are given in Table 3.5.

Table 3.5. Fuel use (kt), mobile combustion in the construction industry.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	38	47	62	68	62	59	41	32

Emission Factors

Emission factors for dioxin from mobile sources are taken Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). They are 0.1 µg/t fuel. PAH emissions are not estimated from this source. SO_2 emissions are calculated from the S-content of the fuels. Emission factors for NOx, CO and NMVOC are taken from Table 1.49 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual.

3.4 Transport (1A3)

3.4.1 Civil Aviation

Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Emissions from civil aviation are estimated as totals, so landings and take-offs for civil aviation are included in civil aviation – cruise. Landing and take-offs in international aviation are included in international aviation – cruise, and not included in national totals.

Activity Data

Total use of jet kerosene and gasoline is based on the NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion are given in Table 3.6.

Table 3.6. Fuel use (kt), domestic aviation.

	1990	1995	2000	2005	2007	2008	2009	2010
Jet kerosene	8.409	8.253	7.728	7.390	6.159	7.601	6.271	6.066
Gasoline	1.681	1.131	1.102	0.872	0.848	0.731	0.649	0.648

Emission Factors

Emission factors for dioxin are taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005) and from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). PAH4 emissions are not estimated. SO_2 emissions are calculated from the S-content of the fuels. Emission factors for NOx, CO and NMVOC are taken from tables 1.9 to 1.11 from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. The emission factors are presented in Table 3.7.

Table 3.7. Emission factors for dioxin, NOx, CO and NMVOC, aviation

	dioxin [µg I-TEQ/t fuel]	NOx [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]
Jet Kerosene	0.06 [2]	300	100	50
Aviation gasoline	2.2 [1]	300	100	50

[1] UNEP 2005, [2] Statistics Norway 2002

Planned Improvements

Planned improvements involve moving emission estimates from aviation to the Tier 2 methodology by next submission and deviate between cruise and landing/take-off emissions.

3.4.2 Road Vehicles

Emissions from Road Traffic are estimated by multiplying the fuel use by type of fuel and vehicle, and fuel and vehicle pollutant specific emission factors.

Activity Data

Total use of diesel oil and gasoline are based on the NEA's annual sales statistics for fossil fuels (Table 3.8.).

Table 3.8. Fuel use (kt), road transport.

	1990	1995	2000	2005	2007	2008	2009	2010
Gasoline	127.812	135.601	142.599	156.730	159.922	155.115	154.932	148.214
Diesel oil	36.567	36.862	47.463	83.478	125.863	113.964	114.491	106.433

NEA estimates on how the fuel consumption is divided between different vehicles groups, i.e. passenger cars, light duty vehicles, and heavy duty vehicles are used for the period 1990 to 2005. From 2006 to 2010 EA estimated how the fuel consumption is divided between the different vehicles groups, using information on the number of vehicles in each group and the driven mileage in each group from the Road Traffic Directorate, using average fuel consumption based on the 1996 IPCC Guidelines regarding average fuel consumption per group. The data for 2006 to 2010 also contains information on motorcycles. The Road Traffic Directorate is working on providing similar data for previous years along with average fuel consumption per group. This work was not finished in time for this submission, but will be included in next submission. Therefore the time series is not fully consistent as two different methodologies are used. For the years 1990 to 2006 emissions from motorcycles are included in emissions from other vehicles.

The EA has estimated the amount of passenger cars by emission control technology. The proportion of passenger cars with three-way catalysts has steadily increased since 1995 when they became mandatory in all new cars. The assumptions are shown in Figure 3.1.

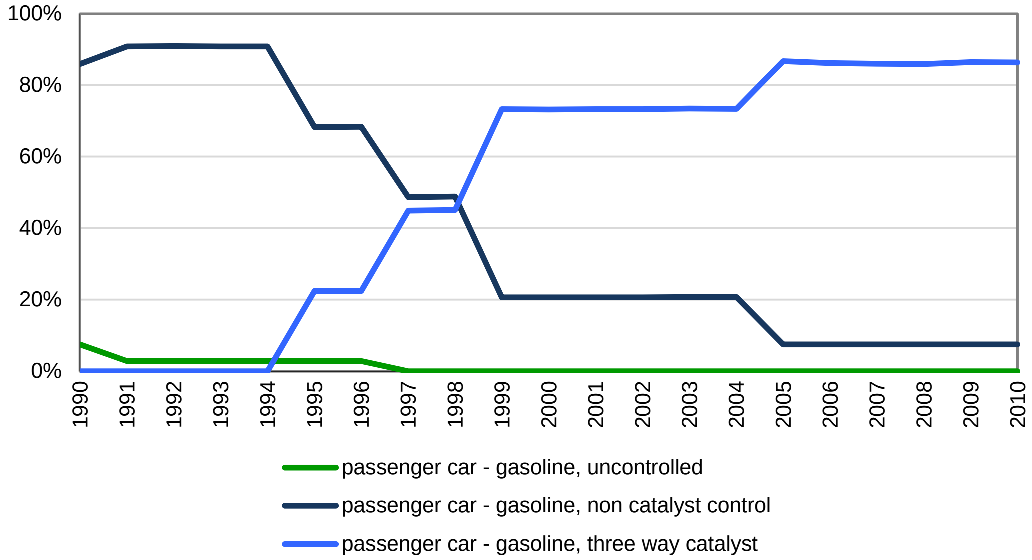

Figure 3.1. Passenger cars by emission control technology.

Emission Factors

Emission factors for dioxin are taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005). They are presented in Table 3.9. Emission factor PAH are taken from the chapter An approach to estimation of PAH emission in the Emission Inventory Guidebook (EEA 2007). Emission factors for PAH4 are presented in Table 3.10.

Table 3.9. Emission factors for dioxin, road vehicles

	dioxin [µg I-TEQ/t fuel]
Gasoline, leaded	2.2
Gasoline, unleaded, no catalyst	0.1
Gasoline, unleaded, with catalyst	0
Gas / Diesel Oil	0.1

Table 3.10. Emission factors for PAH4, road vehicles

	B[a]P [µg/km]	Fuel cons. [L/100 km]	B[a]P µg/kg fuel	ratio to B[a]P		
				B[b]F	B[k]F	I[cd]P
pass.cars gasoline - conventional	1.1	10	14.86	1.2	0.9	1
pass.cars gasoline - catalyst	0.4	10	5.41	0.9	1.2	1.4
light duty vehicles - gasoline	1.1	10	14.86	1.2	0.9	1
pass.cars diesel - direct inj.	0.7	13	6.49	0.9	1	1.1
pass.cars diesel - indirect inj.	2.8	13	25.95	0.9	0.8	0.9
light duty vehicles diesel - direct inj.	0.7	13	6.49	0.9	1	1.1
light duty vehicles diesel - indirect inj.	2.8	13	25.95	0.9	0.8	0.9
HDV (diesel)	1	26	4.63	5.6	8.2	1.4
other use, gas/diesel oil, (HDV)	1	26	4.63	5.6	8.2	1.4

SO_2 emissions are calculated from the S-content of the fuels. Emission factors for other pollutants depend upon vehicle type and emission control. They are taken from tables 1.36 to 1.42 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 3.11.

Table 3.11. Emission factors for NOx, CO and NMVOC for European vehicles.

	NOx [g/kg fuel]	CO [g/kg fuel]	NMVOC [g/kg fuel]
Passenger car – gasoline, uncontrolled	27	550	63
Passenger car – gasoline, non-catalyst control	37	300	72
Passenger car – gasoline, three way catalyst	8.2	45.9	7.1
Light duty vehicle – gasoline	29	360	59
Heavy duty vehicle – gasoline	40	346	32
Motorcycles - gasoline	2.7	730	530
Passenger car – diesel	11	12	3
Light duty vehicle – diesel	16	18	4.6
Heavy duty vehicle – diesel	42	36	8

Recalculations

Since last submission changes have been made regarding how fuel is divided between different vehicles groups for the years 2006 to 2010. The data for 2006 to 2010 also contains information on motorcycles. This has led to minor changes in emissions.

Planned Improvements

Planned improvements involve getting more comprehensive data regarding the fleet composition, mileage driven and fuel consumption from the Road Traffic Directorate for all years and in the near future estimating emissions from road transport with the COPERT model.

3.4.3 National Navigation

Emissions are calculated by multiplying energy use with a pollutant specific emission factor.

Activity Data

Total use of residual fuel oil and gas/diesel oil for national navigation is based on NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion are given in Table 3.12.

Table 3.12. Fuel use (kt), national navigation.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	11.749	7.043	3.425	6.199	5.023	13.179	6.270	8.464
Residual fuel oil	7.170	4.755	0.542	0.881	14.374	4.192	3.709	2.612

Emission Factors

Emission factors for dioxin and PAH (only BbF) are taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). They are presented in Table 3.13.

Table 3.13. Emission factors for dioxin and BbF, navigation

	dioxin [µg I-TEQ/t fuel]	BbF [g BbF/t fuel]	NOx [kg/TJ]	CO [kg/TJ]	NMVOC [kg/TJ]
Gas / Diesel Oil, on ocean	4	0.04	1800	180	52
Residual fuel oil, on ocean	4	0.04	1800	180	52

SO_2 emissions are calculated from the S-content of the fuels. Emission factors for NOx, CO and NMVOC are taken from Table 1.48 in the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships. They are also presented in Table 3.13.

3.4.4 Commercial, Institutional, and Residential Fuel Combustion (1A4a, 1A4b)

Since Iceland relies largely on its renewable energy sources, fuel use for residential, commercial, and institutional heating is low. Residential heating with electricity is subsidized and occurs in areas far from public heat plants. Commercial fuel combustion includes the heating of swimming pools, but only a few swimming pools in the country are heated with oil. Two swimming pools and a school building are heated with heat from waste incineration plants. The resulting emissions are reported here.

Activity Data

Activity data for fuel use is provided by the NEA, which collects data on fuel sales by sector. EA adjusts the data provided by the NEA as further explained in Annex I. Activity data for waste incineration are collected by EA directly. Activity data for fuel combustion and waste incineration in the Commercial/Institutional sector are given in Table 3.14.

Table 3.14. Fuel use (kt), commercial/institutional sector.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	1.8	1.6	1.6	1.0	0.3	0.3	0.3	0.3
Waste oil	3.3	-	-	-	-	-	-	-
LPG	0.3	0.3	0.5	0.5	0.5	0.1	0.1	0.2
Solid waste	-	0.5	0.6	0.6	0.7	0.4	0.3	0.3

Activity data for fuel combustion in the Residential sector are given in Table 3.15. As can be seen in the table the use of kerosene has increased substantially the last two years. Kerosene is used in summerhouses, but also to some extent, in the Commercial sector for heating of commercial buildings. The usage has been very low over the years and therefore the kerosene utilisation has all been allocated to the Residential sector. The increase in usage in the years 2008 to 2010 is believed to be attributed to rapidly rising fuel prices for the Transport sector. This has motivated some diesel car owners to use kerosene on their cars as the kerosene does not have CO_2 tax, despite the fact that it is not good for the engine.

Table 3.15. Fuel use (kt), residential sector.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	8.8	6.4	6.0	3.2	2.4	2.0	2.1	1.9
LPG	0.4	0.5	0.7	0.9	1.1	1.1	1.6	1.4
Kerosene	0.5	0.2	0.1	0.2	0.2	0.8	4.0	1.2

Emission Factors

Emission factors for dioxin from stationary combustion are taken from from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). They are 0.1 µg/t fuel for gas oil and kerosene, 0.06 µg/t fuel for LPG and 4 µg/t for waste oil. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from Table 1.18 and 1.19 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Default EFs from Tables 1.7 to 1.11 in the Reference Manual were used in cases where EFs were not available. Emissions from waste incineration with recovery, where the energy is used for swimming pools/school buildings are reported here. A description of the method for calculating GHG is provided in Chapter 7. The IEF for dioxin in the sector shows fluctuations over the time series. From 1994 onwards waste has been incinerated to produce heat at two locations (swimming pools, school building). The IEF for dioxin for waste is considerably higher than for liquid fuel. Further waste oil was used in the sector from 1990 to 1993. This combined explains the rise in IEF for the whole sector.

Recalculations

Since last submission changes have been made regarding fuel allocation in the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary) and 1A4 Residential, as further explained in Annex III. Further one waste incineration facility (Kalka) which was covered by the sector 1A4 in earlier submissions is now covered by the Waste sector as the plant generates electricity and heat for its own use and is therefore an auto producer.

3.4.5 Agriculture, Forestry, and Fishing (1A4c)

Emissions from fuel use in agriculture and forestry are included elsewhere, mainly within the construction (1A2fii) and Residential sectors (1A4bi); thus, emissions reported here only stem from the fishing fleet. Emissions from fishing are calculated by multiplying energy use with a pollutant specific emission factor.

Activity Data

Total use of residual fuel oil and gas/diesel oil for the fishing is based on the NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion in the Fishing sector are given in Table 3.16.

Table 3.16. Fuel use (kt), fishing sector.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	174.9	191.3	211.1	171.7	129.1	127.7	144.7	128.2
Residual fuel oil	32.4	53.4	16.0	26.3	50.3	36.3	44.6	41.4

Emission Factors

Emission factors for dioxin and PAH (only BbF) are taken from Utslipp til luft av dioxiner i Norge (Statistics Norway, 2002). They are presented in Table 3.13. SO_2 emissions are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from Table 1.48 in the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships. They are also presented in Table 3.13.

3.5 International Bunker Fuels

Emissions from international aviation and marine bunker fuels are excluded from national totals in line with the reporting guidelines under the UNFCCC. Emissions are calculated by multiplying energy use with pollutant specific emission factors.

Activity data is provided by the NEA, which collects data on fuel sales by sector. These data distinguish between national and international usage. In Iceland there is one main airport for international flights, Keflavík Airport. Under normal circumstances almost all international flights depart and arrive from Keflavík Airport, except for flights to Greenland, the Faroe Islands, and some flights with private airplanes which depart/arrive from Reykjavík airport. Domestic flights sometimes depart from Keflavík airport in case of special weather conditions. Oil products sold to Keflavík airport are reported as international usage. The deviations between national and international usage are believed to level out. Emissions estimates for aviation will be moved to Tier 2 methodology by next submissions. A better methodology for the fuel split between international and domestic aviation will be developed in the near future as Iceland will take part in the EU ETS for aviation from 2012 onward and better data will become available. Emission factors for aviation bunkers are the same as described for domestic aviation.

The retail supplier divides fuel use between international navigation (including foreign fishing vessels) and national navigation based on identification numbers which differ between Icelandic and foreign companies. The emission factors for marine bunkers are the same as described for national navigation.

3.6 Geothermal Energy (1B2)

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (26% of the total electricity production in 2010). Geothermal energy is generally considered to have relatively low environmental impact. Emissions of CO_2 are commonly considered to be among the negative environmental effects of geothermal power production, even though they have been shown to be considerably less extensive than from fossil fuel power plants, or 19 times (Baldvinsson et al., 2011). Very small amounts of methane but considerable quantities of sulphur in the form of hydrogen sulphide (H_2S) are emitted from geothermal power plants.

Methodology

The H_2S concentration in the geothermal steam is site and time-specific, and can vary greatly between areas and the wells within an area as well as by the time of extraction. The total emissions estimate of H_2S is based on direct measurements. The enthalpy and flow of each well are measured and the H_2S concentration of the steam fraction determined at the wellhead pressure. The steam fraction of the fluid and its H_2S concentration at the wellhead pressure and the geothermal plant inlet pressure are calculated for each well. Information about the period each well discharged in each year is then used to calculate the annual H_2S discharge from each well and finally the total H_2S is determined by adding up the H_2S discharge from individual wells.

Table 3.17. shows the electricity production with geothermal energy and the total sulphur emissions (calculated as SO_2).

Table 3.17. Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2007	2008	2009	2010
Electricity production (GWh)	283	288	1323	1658	3579	4037	4553	4465
Sulphur emissions (as SO_2, Gg)	13	11	26	30	46	59	53	58

4 Industrial processes

The industrial process sector is important for emissions of dioxins, HCB and PAH4 as well as other pollutants; 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 2010 is shown in Figure 4.1.

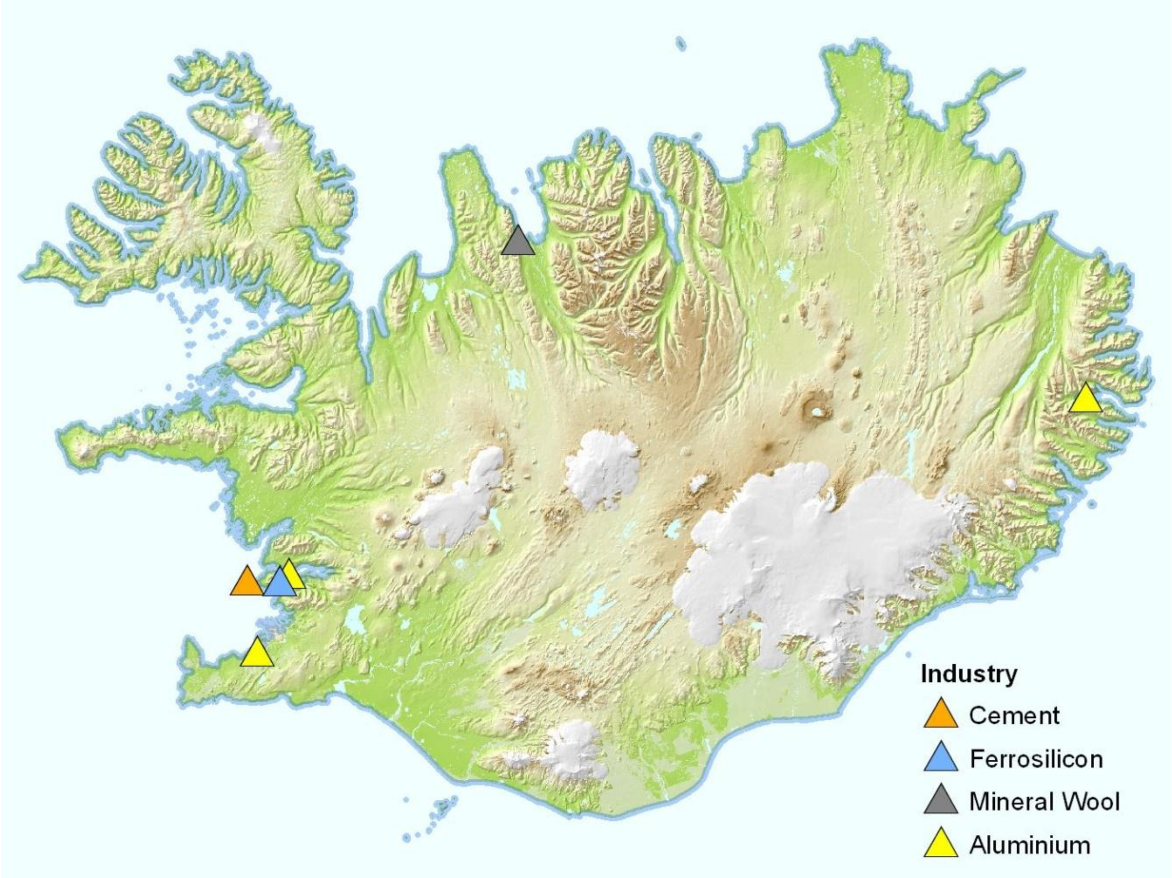

Figure 4.1. Location of industrial facilities in 2010.

4.1 Mineral Industry (2A)

4.1.1 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 2005). The factor applies for wet kilns, with ESP/FF temperature < 200°C and is 0.05 µg I-TEQ/t cement. The HCB emission factor is taken from the chapter Sources of HCB emissions from the Emission Inventory Guidebook (EEA, 2007). Emissions of PAH, NOx, CO and NMVOC originate mainly from combustion and are reported under 1A2fi. Emission estimates for SO_2 are based on measurements.

4.1.2 Road Paving with Asphalt

Asphalt road surfaces are composed of compacted aggregate and asphalt binder. Gases are emitted from the asphalt plant itself, the road surfacing operations, and subsequently from the road surface. Information on the amount of asphalt produced comes from Statistics Iceland. The emission factors for NMVOC are taken from Table 3.1, from Chapter 2.A.6 in the EMEP/EEA emission inventory guidebook (EEA, 2009). Emissions of SO_2, NO_x, and CO are expected to originate mainly from combustion and are therefore not estimated here but accounted for under sector 1A2f.

4.1.3 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. Emissions of SO_2 are based on S-content of the elctrodes used. Emissions of CO are based on measurements. NOx and NMVOC emissions originate from combustion and are reported under sector 1A2f.

4.2 Chemical industry (2B)

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.

At the silicium production plant, silicium containing sludge was burned to remove organic material. Emissions of CO_2 and NO_x were estimated on the basis of the C-content and N-content of the sludge. Emissions also occur from the use of soda ash in the production process and those emissions are reported here.

When the fertilizer production plant was operational it reported its emissions of NO_x and N_2O to the EA.

4.3 Metal Production (2C)

4.3.1 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. Ready-to-use iron pellets for the production are imported so no additional emissions occur from the iron part of the FeSi production. 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). Emission factors for PAH are based on information provided from the ferroalloys plant, assuming that about 45 to 50 kg of PAH4 are emitted per 120,000 t of produced ferrosilicon. This implies an emission factor of 170 mg BaP per tonne of reducing agent, which is within the range of the emission factor given for coal and wood in Appendix 3 in the chapter An approach to estimate PAH emissions in the Emission Inventory Guidebook (EEA 2007). The emission profile is taken from section 7 of the same chapter. Emission factor for CO is 1,62 kg/t FeSi and is taken from table 2.16 and emission factors for NOx and NMVOC are taken from table 1.9 and 1.11 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference manual. Sulphur emissions are calculated from S-content of the reducing agents. Emission factors are presented in Table 4.1.

Table 4.1. Emission factors for dioxin, PAH4, NOx and NMVOC from ferroalloys production

	dioxin [µg I-TEQ/t fuel]	NOx [kg/TJ]	NMVOC [kg/TJ]	BaP [mg/t fuel]	Profile ratio to BaP		
					BbF	BkF	IPy
Coal	1.6	300	20	170	0.05	0.01	0.8
Coke	1.6	300	20	170	0.05	0.01	0.8
Charcoal	1.6	300	20	170	0.05	0.01	0.8
Waste wood	1	100	50	170	0.05	0.01	0.8
Electrodes	1.6	300	20	170	0.05	0.01	0.8

4.3.2 Primary Aluminium Production

In 2010 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. Emissions of SO_2 are estimated from S-content of alumina and electrodes.

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 4.1. 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.

In 2011 dioxin was measured at all three plants. The possibility of using those measurements to improve emission estimates will be further explored.

4.3.3 Secondary Aluminium Production

In 2004 a secondary aluminium production plant was established in Iceland. The plant recycles scrap aluminium from the two primary aluminium plants in southwest of Iceland. The scrap metal is melted in batches in a rotary kiln. Emissions of dioxin and HCB are estimated. Activity data is taken from green accounts. The dioxin emission factor comes from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005). The lowest value (0.5 µg/t aluminium) for secondary aluminium production was chosen as the plant only recycles scrap metal from primary aluminium plants and no coated aluminium, so organic compounds in the input material is minimum. Also no chlorine is added in the process and further oxy-fuel burners are used. The HCB emission factor (5 g/t) is taken from the chapter Sources of HCB emissions from the Emission Inventory Guidebook (EEA, 2007).

4.4 Other Production (2D)

Other production in Iceland is the Food and Drink Industry. NMVOC emissions from this sector have now been estimated for the first time. Production statistics were obtained by Statistics Iceland for beer, fish, meat and poultry for the whole time series (Figure 4.2). Statistics for coffee roasting and animal feed were available for the years 2005 to 2010. Production statistics were extrapolated for the years 1990 to 2004. No information was available for production of bread, cakes and biscuits. Emission factor for NMVOC were taken from Tables 2-24 and 2-25 in the 1996 IPCC Guidelines.

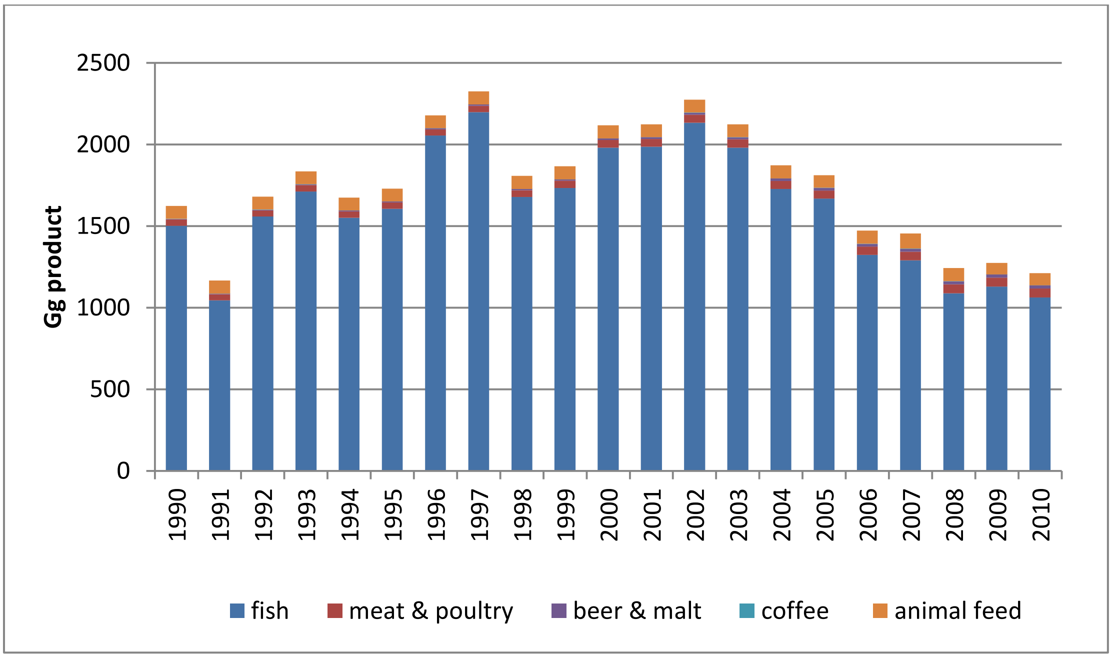

Figure 4.2. Fish, meat & poultry, beer & malt, coffee, and animal feed production in Iceland.

5 Solvent and other product use

This chapter describes mainly non-methane volatile organic compounds (NMVOC) emissions from solvents. When volatile chemicals are exposed to air, emissions are produced through evaporation of the chemicals. The use of solvents and other organic compounds in industrial processes and households is important source NMVOC evaporation. Emissions of other pollutants than NMVOC only stem from other use of products, sector 3D3, namely from preservation of wood and use of tobacco.

Methodology

NMVOC emissions are estimated according to the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009).

Source Specific QA/QC Procedures

The QC activities include general methods such as accuracy checks on data acquisition and calculations as well as the use of approved standardised procedures for emission calculations, estimating uncertainties, archiving information and reporting. Further information can be found in the QA/QC manual.

5.1 Paint application (3A)

Methodology, activity data and emission factors

The categories Paint application, Degreasing, and Other NMVOC emissions from printing and other product use have in common that their activity data consists of data about imported goods. This data was received from Statistics Iceland.

The EMEP guidebook (EEA, 2009) provides emission factors based on amounts of paint applied. Data exists on imported paint since 1990 (Statistics Iceland, 2012) and on domestic production of paint since 1998 (Icelandic recycling fund, 2012). The Tier 1 emission factor refers to all paints applied, e.g. waterborne, powder, high solid and solvent based paints. The existing data on produced and imported paints, however, permits to narrow activity data down to conventional solvent based paints. Therefore Tier 2 emission factors for conventional solvent based paints could be applied. The activity data does not allow for a distinction between decorative coating application for construction of buildings and domestic use of paints. Their NMVOC emission factors, however, are identical: 230 g/kg paint applied. It is assumed that all paint imported and produced domestically is applied domestically during the same year. Therefore the total amount of solvent based paint is multiplied with the emission factor. For the time before 1998 no data exists about the amount of solvent based paint produced domestically. Therefore the domestically produced paint amount of 1998, which happens to be the highest of the time period for which data exists, is used for the period from 1990-1997. The amounts of solvent based paint produced domestically and imported are shown in Figure 5.1.

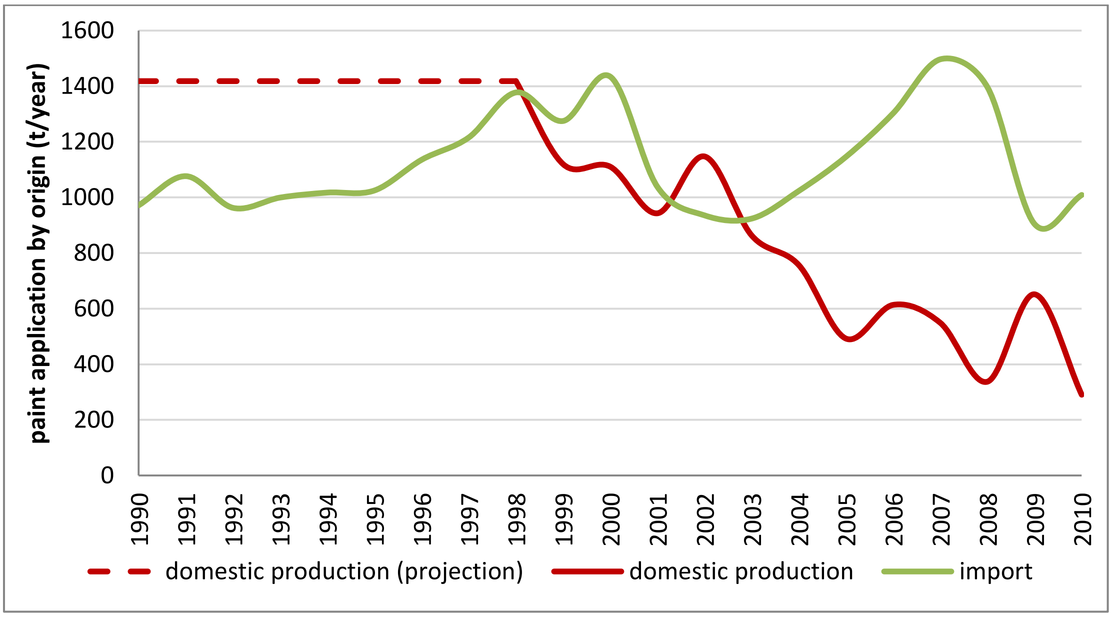

Figure 5.1. Amounts of solvent based paints imported and produced domestically

Recalculations, improvements and planned improvements

There have been slight changes to the use of data on imported paints. Solvent based wood preservatives that were included before are now allocated to 3D. There are a number of product types not included in the last submission, which are included in this submission. Examples are colour lakes, paints for artistic and educational purposes and sealing varnish. Paint thinners that were allocated to degreasing are now included under paint application. Until now domestic production of solvent based paints had been estimated. This year it is based on production data provided by the Icelandic recycling fund from 1998-2010 (Icelandic recycling fund, 2012). Until last year NMVOC emissions were calculated by multiplying the activity data with 0.5. Now the Tier 2 emission factor for conventional solid based paints of 0.23 is applied. Because of the changes in activity data and emission factors NMVOC emissions decreased between submissions by 52% in 1990 and by 67% in 2009. For next year´s submission it is planned to make an effort to determine domestic paint production from 1990-1997.

5.2 Degreasing and dry cleaning (3B)

Methodology, activity data and emissions

The EMEP guidebook provides a Tier 1 emission factor for degreasing based on amounts of cleaning products used. There is data on the amount of cleaning products imported provided by Statistics Iceland. Of the chemicals listed by the EMEP guidebook activity data is available for: methylene chloride (MC), tetrachloroethylene (PER), trichloroethylene (TRI) and xylenes (XYL). In Iceland, though, PER is mainly used for dry cleaning (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported PER was allocated to degreasing. Emissions from dry cleaning are estimated without using data on solvents used (see below). The use of PER in dry cleaning, though, is implicitly contained in the method. In Iceland, xylenes are mainly used in paint production (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported xylenes were allocated to degreasing. Emissions from paint production are estimated without using data on solvents used but xylene use is implicitly contained in the method. In addition to the solvents mentioned above, 1,1,1,- trichloroethylene (TCA), now banned by the Montreal Protocol, is added for the time period during which it was imported and used. Another category included is paint and varnish removers. The amount of imported solvents for degreasing was multiplied with the NMVOC Tier 1 emission factor for degreasing: 460 g/kg cleaning product.

Emissions from dry cleaning were calculated using the Tier 2 emission factor for open-circuit machines provided by the EMEP guidebook. Activity data for calculation of NMVOC emissions is the amount of textile treated annually, which is assumed to be 0.3 kg/head (EMEP guidebook default) and calculated using demographic data. The NMVOC emission factor for open-circuit machines is 177g/kg textile treated. Since all dry cleaning machines used in Iceland are conventional closed-circuit PER machines, the emission factor was reduced using the respective EMEP guidebook reduction default value of 0.89. NMVOC emissions from dry cleaning were calculated thus:

$$E_{NMVOC}(t) = \text{population}(t) \bullet 0.3 \bullet (177/1000) \bullet (1-0.89)$$

Where:
$E_{NMVOC}(t)$ = emissions of NMVOC in year t, kg
Population (t) = population in year t
0.3 = amount of textiles treated inhabitant/year, kg
177 = g NMVOC emissions/kg textile treated
0.89 = abatement efficiency of closed circuit PER machines

Recalculations, improvements and planned improvements

Until this submission degreasing and dry cleaning were not itemized as emission sources of NMVOC, but shared activity data and emission factors. The emission factors for solvent use in degreasing and dry cleaning differ from each other. Therefore both technologies are treated separately in this submission. The activity data used before for both degreasing and dry cleaning is now allocated to degreasing with the following exceptions. Half of the PER imported is not allocated to degreasing since it is mainly used in dry cleaning. Emissions from PER use in dry cleaning are implied by the method reported for conventional closed circuit PER machines. Paint thinners that were allocated to degreasing/dry cleaning are now allocated to paint application. Xylenes that were allocated to other NMVOC emissions are now partly allocated to degreasing and partly implicated in paint production. In the last submission an emission factor of 1 was assumed for both technologies. In this submission the emission factors supplied by the EMEP guidebook, i.e. 460 g/kg cleaning product for degreasing and 177 g/kg treated textile for dry cleaning (reduced with an abatement efficiency of 89%) were applied. Because of the changes in activity data and emission factors NMVOC emissions decreased between submissions by 64% in 1990 and 59% in 2009.

For next year´s submission it is planned to determine the amount of imported PER and xylenes not allocated to degreasing more accurately and to review the customs codes applied in the source category.

5.3 Chemical products (3C)

Methodology, activity data and emissions

The only activity identified for the subcategory chemical products, manufacture and processing is manufacture of paints. NMVOC emissions from asphalt blowing, included in the EMEP guidebook under chemical products, are covered in the industry sector (not occurring in Iceland). NMVOC emissions from the manufacture of paints were calculated using the EMEP guidebook Tier 2 emission factor of 11 g/kg product. The activity data consists of the amount of paint produced domestically as discussed above in chapter 0.

Recalculations, improvements and planned improvements

NMVOC emissions from manufacture of paint had not been estimated in preceding submissions. For next year´s submission it is planned to determine domestic paint production from 1990-1997.

5.4 Other product use (3D)

5.4.1 Printing

NMVOC emissions for printing were calculated using the EMEP guidebook Tier 1 emission factor of 500g/kg ink used. Import data on ink was received from Statistics Iceland (Statistics Iceland, 2012).

5.4.2 Other domestic use of solvents

NMVOC emissions from other domestic use were calculated using the EMEP guidebook emission factor of 1 kg/inhabitant/year.

5.4.3 Other product use

Wood preservation

Wood is preserved to protect it against fungal and insect attack and also against weathering. There are three main types of preservative: creosote, organic solvent-based (often referred to as ‘light organic solvent-based preservatives (LOSP)’) and water borne. Creosote is oil prepared from coal tar distillation. Creosote contains a high proportion of aromatic compounds such as polycyclic aromatic hydrocarbons (PAHs). Activity data consists of annual import of creosotes and the assumption that all imported creosote is applied during the year of import. Emission factors for PAH are taken from chapter 3.D.3 of the Emission Inventory Guidebook (EEA, 2009). They are 0.5 mg BaP per kilogramme of creosote, 0.25 mg per kilogramme creosote of the other 3 PAH: BbF, BkF and IPy. NMVOC emissions from wood preservation were calculated using the EMEP guidebook Tier 2 emission factors for creosote preservative type (110 g/kg creosote) and organic solvent borne preservative (900 g/kg preservative). Import data on both wood preservatives was received from Statistics Iceland (Statistics Iceland, 2012).

Use of tobacco (smoking)

Tobacco smoking is a minor source of dioxins, PAH and other pollutants. Activity data consists of all smoking tobacco imported and is provided by Statistics Iceland (Statistics

Iceland, 2012). Emissions factor are taken from table 3-9 in chapter 3.D.3 in the Emission Inventory Guidebook (EEA, 2009). They are presented in Table 5.1.

Table 5.1. Emission factors from tobacco smoking

	dioxin [ng I-TEQ/t]	PAH4 [mg/t]	NOx [g/t]	CO [g/t]	NMVOC [g/t]
Tobacco	1.3	0.04	3.5	122	4.8

Recalculations, improvements and planned improvements

In preceding submissions other NMVOC emissions from product use were calculated adding the following substances imported: toluene, xylenes, naphthalene, low viscosity oils and part of the white spirit import. It was assumed that 80% of the white spirit was used for domestic paint production and the amount imported was reduced accordingly. This submission was calculated along the 2009 EMEP guidelines and therefore used other approaches calculating emissions from other product use. Because of the changes in activity data and methodology used, NMVOC emissions decreased between submissions by 71% for 1990 but increased by 40% for 2009. Emissions of PAH4, NOx, CO and NMVOC from tobacco smoking are estimated for the first in this submission.

6 Agriculture

Icelanders are self-sufficient in all major livestock products, such as meat, milk, and eggs. Traditional livestock production is grassland based and most farm animals are native breeds, i.e. dairy cattle, sheep, horses, and goats, which are all of an ancient Nordic origin, one breed for each species. These animals are generally smaller than the breeds common elsewhere in Europe. Beef production, however, is partly through imported breeds, as is most poultry and all pork production. There is not much arable crop production in Iceland, due to a cold climate and short growing season. Cropland in Iceland consists mainly of cultivated hayfields, but potatoes, barley, beets, and carrots are grown on limited acreage.

Methane and nitrous oxide emissions from agriculture are estimated. Emissions under the LRTAP have not been estimated for the Agriculture sector in Iceland.

7 Waste

For most of the 20th century solid waste disposal sites (SWDS) in Iceland were numerous, small and located close to the locations of waste generation so that the waste did not have to be transported far for disposal. In 1967 the waste disposal site in Gufunes was set into operation and most of the waste of the capital´s population landfilled there. Prior to that year, the waste of the capital area was landfilled in smaller SWDS.

Until the 1970s the most common form of waste management outside the capital area was open burning of waste. In some communities waste burning was complemented with landfills for bulky waste and ash. The existing landfill sites did not have to meet specific requirements regarding location, management and aftercare before 1990 and were often just holes in the ground. Some communities also disposed of their waste by dumping it into the sea. Akureyri and Selfoss, two of the biggest communities outside the capital area opened municipal SWDS in the 1970s and 1980s.

Before 1990 three waste incinerators were opened in Keflavík, Húsavík and Ísafjörður. Totalled up they burned around 15,000 tonnes of waste annually. They operated at low or varying temperatures and the energy produced was not utilised. Waste incineration in Iceland as such started in 1993 with the opening of the incineration plant in Vestmannaeyjar, an archipelago to the south of Iceland. Six more incineration plants were opened until 2006. In 2010 a total of six waste incinerator plants were in use. Some of them recover energy and use it for either public or commercial heat production. Open burning of waste was banned in 1999 and is non-existent today (2012). The last place to burn waste openly was the island of Grímsey which stopped doing so during 2011.

Recycling and biological treatment of waste started on a larger scale in the beginning of the 1990s. Their share of total waste management increased rapidly since then.

Reliable data about waste composition does not exist until recent years. In 1991 the waste management company Sorpa ltd. started serving the capital area and has gathered data about waste composition of landfilled waste since 1999. For the last few years the waste sector has had to report data about amounts and kinds of waste landfilled, incinerated, and recycled.

The special treatment of hazardous waste did not start until the 1990s, i.e. hazardous waste was landfilled or burned like non-hazardous waste. Special treatment started with the reusing of waste as energy source. In 1996 the Hazardous waste committee (*Spilliefnanefnd*) was founded and started a collection scheme for hazardous waste. The collection scheme included fees on hazardous substances that were refunded if the substances were delivered to hazardous waste collection points. Hazardous substances collected included oil products, organic solvents, halogenated compounds, isocyanates, oil-based paints, printer ink, batteries, car batteries, preservatives, refrigerants, and more. After collection, these substances were destroyed, recycled or exported for further treatment. The Hazardous waste committee was succeeded by the Icelandic recycling fund in late 2002. In 2010, 953 tonnes of hazardous waste were landfilled, 523 tonnes were incinerated, 4560 tonnes were recycled, and 343 tonnes of acid were neutralized.

Clinical waste has been incinerated in incinerators either at hospitals or at waste incineration plants. 160 tonnes of clinical waste were incinerated in 2010.

The trend in waste management practices has been toward managed SWDS as municipalities have increasingly cooperated with each other on running waste collection schemes and operating joint landfill sites. This can be seen in Figure 7.1 and Figure 7.2, which show different waste management practices in 1990 and 2010. This has resulted in larger SWDS and enabled the shutdown of a number of small sites. In 2010, almost 80% of all landfilled waste was disposed of in managed SWDS. Recycling of waste has increased due to efforts made by the government, local municipalities, recovery companies, and others. Composting started in the mid-1990s and has increased since then.

In 2010, about 34% of all waste generated was landfilled, 58% recycled or recovered, 4% incinerated, and 3% composted.

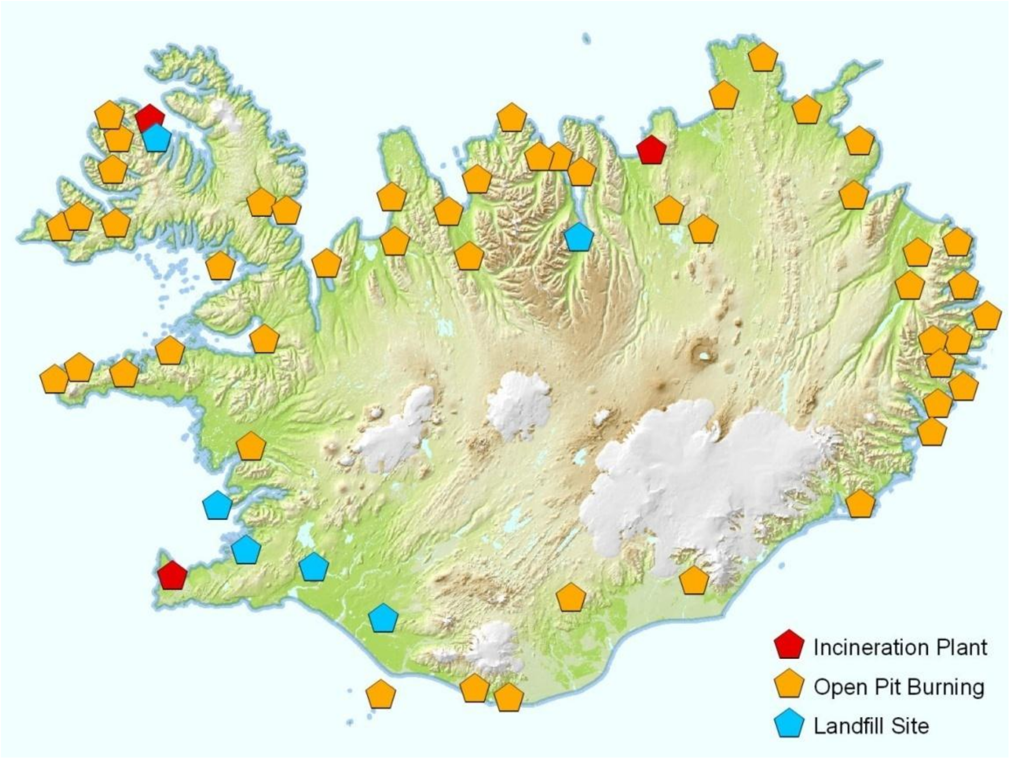

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Figure 7.1. Waste management practices in 1990

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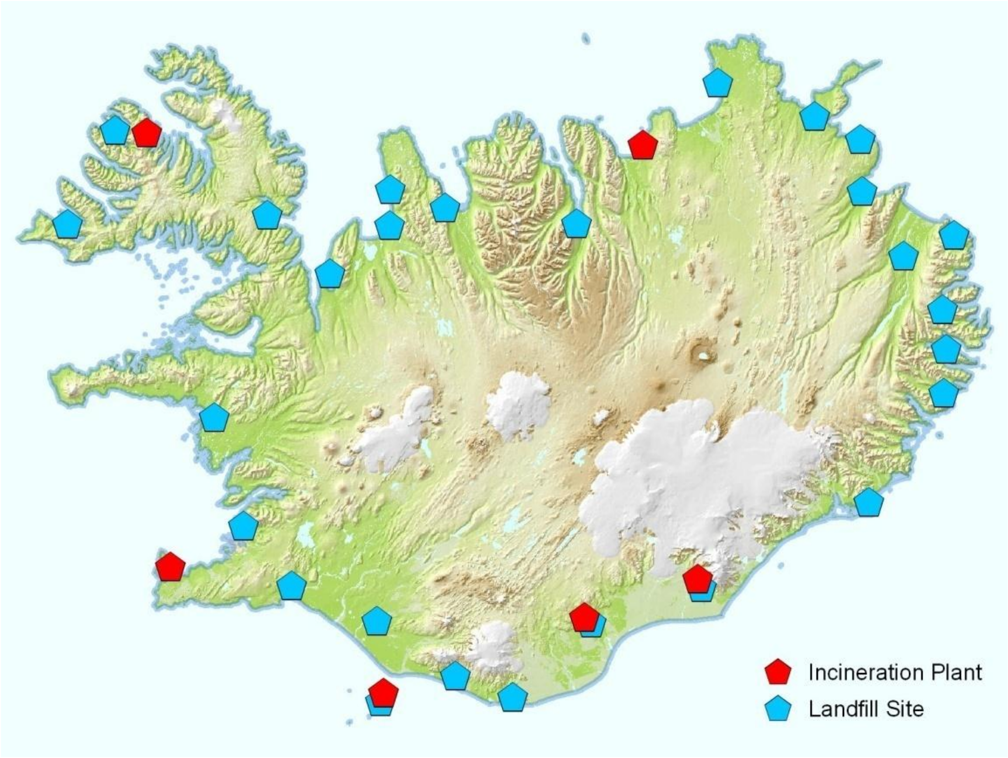

Figure 7.2. Waste management practices in 2010.

7.1 Solid waste disposal on land (6A)

Major emissions from waste disposal at landfill sites are emissions of greenhouse gases. It is assumed that emissions of small quantities of NMVOC, CO, NH_3 and NOx occur at landfill sites. PM emissions are emitted from waste handling as well, but no emission factors are available. Only the emissions of greenhouse gases have been estimated from this source category.

7.2 Waste water handling (6B)

According to the Emission Inventory Guidebook waste-water handling can be a source for emissions of POPs, NMVOC, NH_3 and CO. Of these pollutants only NMVOC is thought to be significant. Only the emissions of greenhouse gases have been estimated from this source category.

7.3 Waste incineration (6C)

This chapter deals with incineration, open burning of waste, bonfires and cremation. Incineration of waste is subdivided into incineration with energy recovery and incineration without energy recovery.

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.

In 1993 incineration plants were opened on the Vestmannaeyjar archipelago and in Svínafell in southeast Iceland. These two plants and the next two, which were opened in 1995 (Ísafjörður) and 1999 (Skaftárhreppur) recover the energy of the incineration and use it for either public heat production (Vestmannaeyjar, Ísafjörður) or commercial/institutional heat production (Svínafell, swimming pool; Skaftárhreppur, swimming pool, school building). The incineration plant Kalka (established in 2005) produces energy and electricity for its own requirements and therefore rates as auto producer. Thus it is categorized as incineration plant without energy recovery as are the two remaining incineration plants: Húsavík in northeast Iceland (established in 2006) and Tálknafjörður, which operated only from 2001 to 2004. 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 7.1.

Table 7.1. Waste incineration from 1990 to 2010, thousand tonnes

Year	Incineration with energy recovery (1A1a)	Incineration with energy recovery (1A4)	Incineration plants (6C)	Open pit burning
1990	-	-	-	33.8
1991	-	-	-	33.5
1992	-	-	-	32.6
1993	3.7	0.5	-	27.8
1994	3.7	0.5	-	25.6
1995	4.7	0.5	-	22.6
1996	6.1	0.5	-	20.2
1997	6.1	0.5	-	19.5
1998	6.1	0.5	-	16.5
1999	6.1	0.6	-	13.5
2000	6.1	0.6	-	12.7
2001	6.1	0.6	0.2	11.6
2002	6.1	0.6	0.2	10.8
2003	6.1	0.9	0.2	9.1
2004	6.2	0.8	9.8	4.3
2005	5.4	0.5	9.8	0.05
2006	7.6	0.6	14.1	0.05
2007	8.2	0.7	17.1	0.05
2008	6.3	0.4	15.7	0.05
2009	5.5	0.4	15.3	0.05
2010	4.8	0.4	12.7	0.05
Trend 1990 - 2010	-	-	-	-99.8%

Emission factors

Emission factors for dioxin for waste incineration are based on measurements at the plants, except for Kalka which reports its emissions. Several point measurements exist in the period 2007 to 2011. Average emission at similar incineration plants (Hoval technique) at Ísafjörður, Skaftárhreppur and Vestmannaeyjar was close to 50 µg/t. As all these incineration plants are operated as batch, an emission factor for those plants was chosen to be 100 µg/t. The incineration plant at Ísafjörður was closed down in 2010, after a period of malfunctioning. No dioxin measurements took place at the plant for the last three years of operation. Other pollutants were measured at the plant, indicating that there were significantly more emissions of all pollutants for the last three years of operation. For those years the emission factor of 300 µg/t for uncontrolled domestic waste burning was taken from the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005). This factor is also used for the incineration plant at Svínafell (also Hoval technique), based on measurements. For the incineration plant at Húsavík an emission factor of 10 µg/t was chosen, based on measurements. Emission factors for PAH, HCB, NO_x, SO_2, CO, and NMVOC are taken from table 3.1 in chapter 6.C.c of the Emission Inventory Guidebook (EEA, 2009). They do not differentiate between different incinerations techniques and are applied to the total waste amount incinerated. The emission factors are presented in Table 7.2.

Table 7.2. Emission factors for dioxin, HCB, PAH, NOx, CO, NMVOC and SO_2 from waste incineration

	dioxin [µg I-TEQ/t]	BaP [mg/t]	BbF [mg/t]	BkF [mg/t]	HCB [mg/t]	NOx [kg/t]	CO [kg/t]	NMVOC [kg/t]	SO_2 [kg/t]
Open pit burning	300	0.7	3.15	3.15	2	1.8	0.7	0.02	0.4
Hoval technique*	100	0.7	3.15	3.15	2	1.8	0.7	0.02	0.4
Húsavík	10	0.7	3.15	3.15	2	1.8	0.7	0.02	0.4
Kalka	Reported	0.7	3.15	3.15	2	1.8	0.7	0.02	0.4

* The incineration plant at Svínafell is classified as open pit burning

Open pit burning

Open burning of waste includes combustion in nature and open dumps as well as combustion in incineration devices that do not control the combustion air to maintain adequate temperature and do not provide sufficient residence time for complete combustion. Incineration devices on the other hand are characterised by creating conditions for complete combustion. Therefore the burning of waste in historic incineration devices that did not ensure conditions for complete combustion is allocated to open burning of waste. As can be seen from Table 7.1 open pit burning was a common procedure in the early nineties. In general open pit burning results in poor combustion conditions due to inhomogeneous and poorly mixed fuel material, chlorinated precursors, humidity or catalytically active metals, but all these factor influence the dioxin formation. It can therefore be hard to come up with a reasonable emission factors. In addition to that the activity data is quite uncertain as well, as no official statistics are available. Historic data on open pit burning 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 in 1990, 1995 and 2000 and interpolated in the years between. These communities were mapped by EA in the respective years. It is known at the EA when sites, where open pit burning has been performed, have been closed down and other means of waste disposal have been found. Open pit burning is likely to occur still at various sites, but this has not been estimated. The amount of waste burned in open pits has decreased rapidly since the early 1990s, when more than 30 thousand tonnes of waste were burned. Between 2005 and 2011 there was only one place left burning waste openly: the island of Grímsey. It was assumed that around 50 tonnes of waste were burned there annually.

Emission factor for dioxin for open pit burning are taken from table 54 in the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005), it is 300 µg per tonne waste (given for uncontrolled domestic waste burning). Emission factors for PAH4, HCB, NOx, CO, NMVOC and SO_2 are taken from table 3.1 in chapter 6.C.c of the Emission Inventory Guidebook (EEA, 2009). They are presented in Table 7.2 above.

Bonfires

It is a tradition to light up bonfires at New Year's Eve in Iceland. These are quite common throughout the country. In the early nineties there were no restrictions and no supervision with these bonfires. In the early nineties some surveillance officers from the Environmental and Public Health Offices (Local Competent Authority) started to control these fires, by informing the bonfire personnel. In 2000 the EA, Iceland Fire Authority and National Commissioner of Iceland Police published guidelines for bonfires. They include restrictions on size, burnout time and the material allowed. Since that time only wood and paper are allowed on bonfires. Also the Environmental and Public Health Offices supervise all bonfires. Now they are fewer and better organized.

Activity data is not easily obtained. In 2011 the EA along with the municipality of Reykjavík decided to weigh all the material of a single bonfire. Then the piled material was photographed and height, width and length measured. The weight was then correlated to the more readily measureable parameters pile height and diameter. The Environmental and Public Health Offices were asked to measure height and diameter of the bonfires in their area, take pictures and send to EA. From this information the total weight of bonfires was estimated for the whole country. The amount was further extrapolated back to 1990, in cooperation with an expert from one Environmental and Public Health Office that has been involved with this field of work for a long time.

Emission factor are also difficult to estimate. From 2003 onwards an emission factor of 60 µg/t is used. This factor is taken from table 54 of the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2005) and is given for open burning of wood. For 1990 to 1995 an emission factor of 600 µg per tonne burnt material was used. This relates to the fact that the burning material was very miscellaneous at that time. It was common practice to burn tires, kitchen interior and even boats at the bonfires. Further some businesses used the opportunity to get rid of all kind of wastes. Therefore it was considered suitable to double the emission factor used for open pit burning. The emission factor was then interpolated from 600 µg to 60 µg per tonne burned material from 1996 to 2003. The emission factors for other pollutants than dioxin are the same as for waste incineration, as presented in Table 7.2 above.

Cremation

Cremation is performed at a single facility, located in Reykjavík. Human bodies are incinerated along with the coffin. The heat at the combustion chamber reaches high temperatures. Emissions of dioxins and PAH (emission factor is only given for BaP) are estimated. Activity data was collected from the single facility. Emission factors are 0.0168 µg/body for dioxin and 0.0103 µg/body for BaP. They are taken from the Emission Inventory Guidebook (EEA, 2009).

7.4 Other waste

This section deals with emissions from accidental vehicle and building fires. Emissions from landfill fires have not been estimated.

Vehicle fires

It was not possible to obtain activity data from the Iceland Construction Authority, in time for this submission. Therefore Danish emissions estimates have been scaled to Icelandic vehicle data to come up with emission estimates for Iceland. This has been done for dioxin and PAH4.

In the Danish IIR, emissions from vehicle fires are calculated by multiplying the number of vehicle fires with selected emission factors. Emission factors are not available for different vehicle types, whereas it is assumed that all the different vehicle types leads to similar emissions. The activity data is calculated as an yearly combusted mass by multiplying the number of different vehicles fires with the Danish registered average weight of the given vehicle type. For the Icelandic emission estimate, the average Danish ratio of vehicle fires were taken per vehicle type (passenger cars, 0.086%; buses 0.432%; light duty vehicles 0.033%; heavy duty vehicles 0.320%; motorcycles 0.185%) and used with Icelandic data on registered vehicles. The total amount of vehicle involved in fires is then calculated from the number of vehicle fires and the average weights of the different vehicle types (also Danish weight, as information was not available). It is assumed that 70% of the total vehicle mass involved in a fire actually burns. The burned mass is then multiplied with emission factors for dioxin and PAH4. They are taken from the Annual Danish Informative Inventory Report to the UNECE (National Environmental Research Institute, 2011). This leads to more increase in emissions in Iceland from this source than from Denmark as the Icelandic vehicle fleet has grown more in the period than the Danish fleet. The possibility to obtain data from Iceland Construction Authority will be further explored.

Building fires

It was not possible to obtain activity data from the Iceland Construction Authority, in time for this submission. Therefore Danish emissions estimates have been scaled to population to come up with emission estimates for Iceland. This has been done for dioxin and PAH4. This leads to more increase in emissions in Iceland from this source as from Denmark as the Icelandic population has grown by 25% from 1990 to 2010, as the Danish population grew by 8%. The possibility to obtain data from Iceland Construction Authority will be further explored.

In the Danish IIR emissions from building fires are calculated by multiplying the number of building fires with selected emission factors. Four types of buildings are separated with different emission factors: detached houses, undetached houses, apartment buildings and industrial buildings. Activity data for building fires are classified in three categories: large, medium and small. The emission factors comply for full scale building fires and the activity data is therefore recalculated as a full scale equivalent where it is assumed that a medium and a small fire leads to 50% and 5% of a large fire respectively, and that a large fire is a full scale fire.

8 Other and natural emissions

Iceland reports emissions from volcanos in 2010 as Eyjafjallajökull erupted. Emissions of sulphur dioxide and particulate matter were estimated and reported. The emissions estimates are based on satellite observation on a daily basis during the eruption (https://wiki.met.no/emep/emep_volcano_plume).

Table 8.1 Eruption emission parameters.

	PM10 [kg/s]	PM2.5 [kg/s]	SO2 [kg/s]	height [km]
14.4.2010	1,00E+03	2,80E+02	15	8
15.4.2010	5,00E+03	1,40E+03	46	7
16.4.2010	5,00E+03	1,40E+03	15	7
17.4.2010	9,00E+03	2,50E+03	10	7
18.4.2010	2,00E+03	5,60E+02	10	5
19.4.2010	7,00E+03	2,00E+03	20	5
20.4.2010	3,00E+02	8,40E+01	15	4
2010-04-21—2010-04-29	3,00E+02	8,40E+01	15	3
2010-04-30—2010-05-02	3,00E+02	8,40E+01	15	4
2010-05-03—2010-05-04	2,00E+03	5,60E+02	15	5
5.5.2010	2,00E+03	5,60E+02	70	5
2010-05-06—2010-05-20	2,00E+03	5,60E+02	70	6
21.5.2010	1,00E+02	2,80E+01	5	3
22.5.2010	1,00E+02	2,80E+01	2	3
23.5.2010	0	0	1	2
2010-05-24—today	0	0	0	0

9 Spatially distributed emissions on grid

Geographically distributed emissions, are reported for the years 1990, 1995, 2000, 2005 and 2010 for dioxin and PAH4. Emission data have been disaggregated to the standard EMEP grid with a resolution of 50km x 50km. The reported emissions include gridded data for sector totals as well as national totals. Emissions for aviation, navigation and fishing have not been gridded.

When gridding the data all industrial sources and waste incineration sites (open pit burning and incineration plants) have been mapped with coordinates and projected on the grid. Other emissions like emissions from road transport, accidental fires, and bon fires have been divided on the grid based on population data. Some minor sources like emissions from tobacco smoking have been located where the populations density is highest, i.e. the capital area.

Figures 9.1 to 9.5 show national total emissions of PAH4 within the EMEP-Grid in 1990, 1995, 2000, 2005 and 2010.

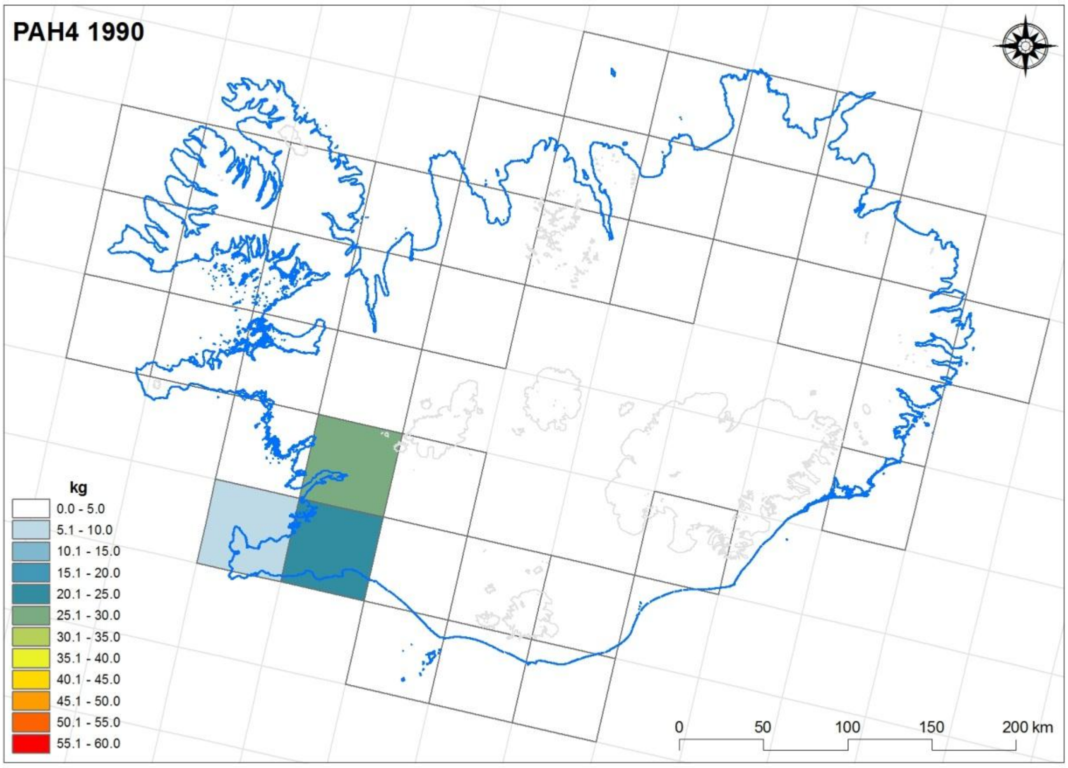

Figure 9.1. **Emissions of PAH4 within the EMEP-Grid in 1990.**

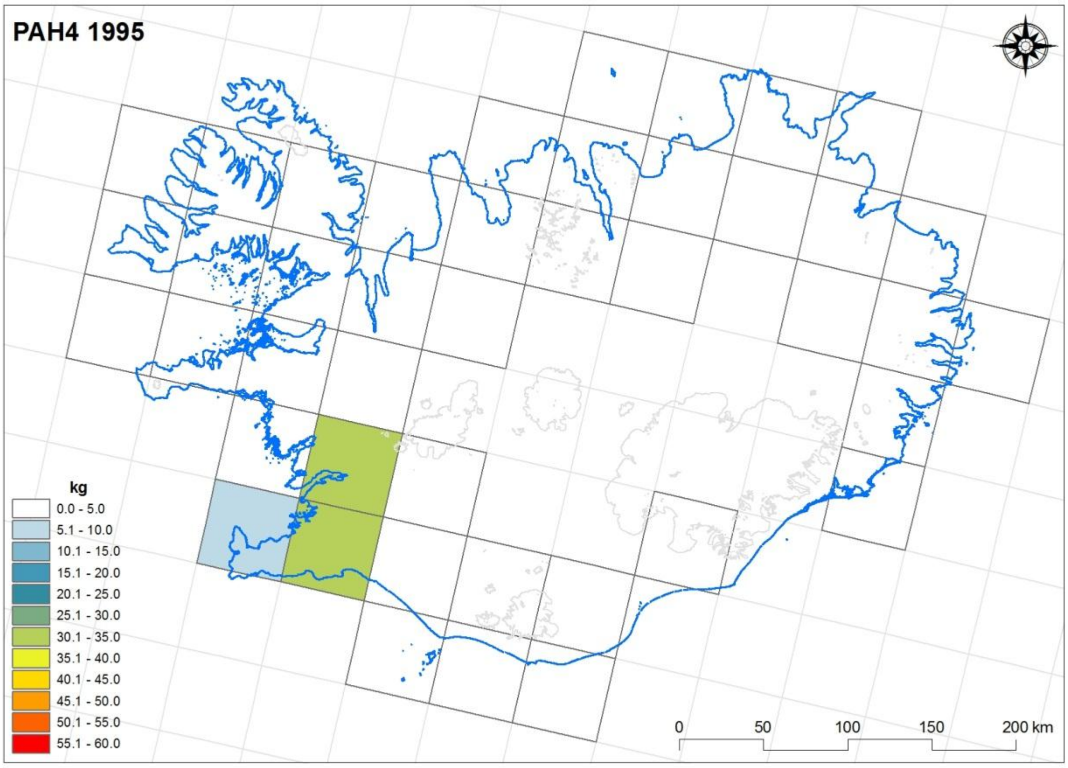

Figure 9.2 Emissions of PAH4 within the EMEP-Grid in 1995.

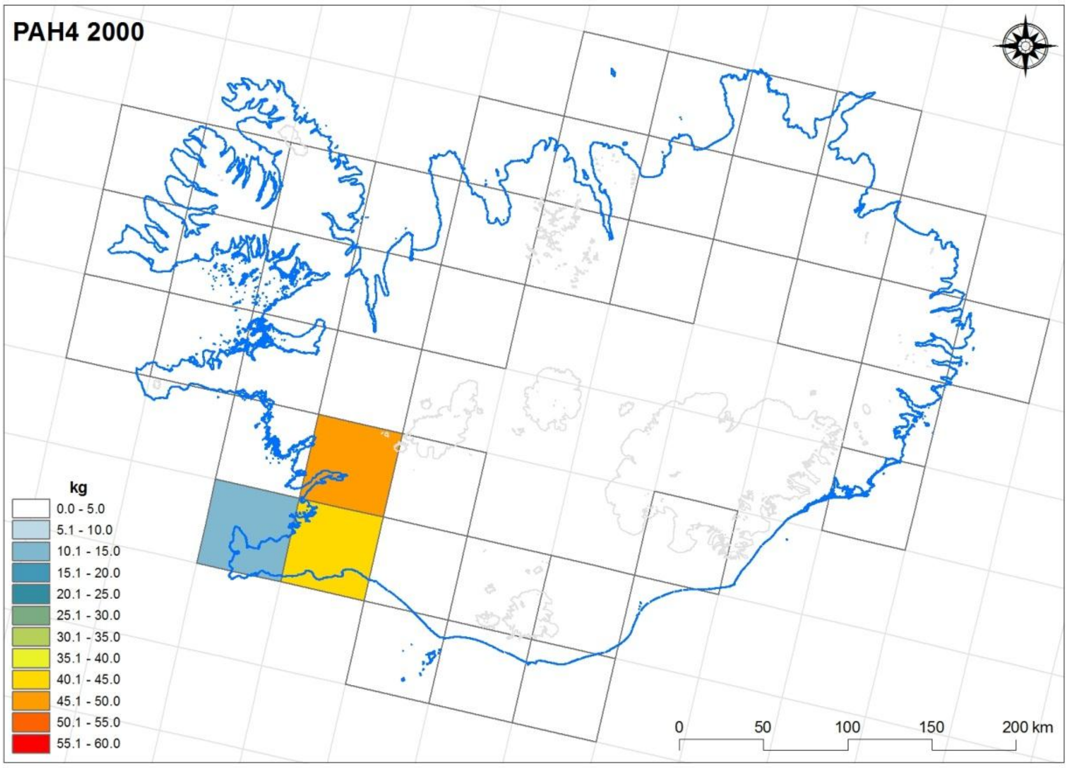

Figure 9.3. Emissions of PAH4 within the EMEP-Grid in 2000.

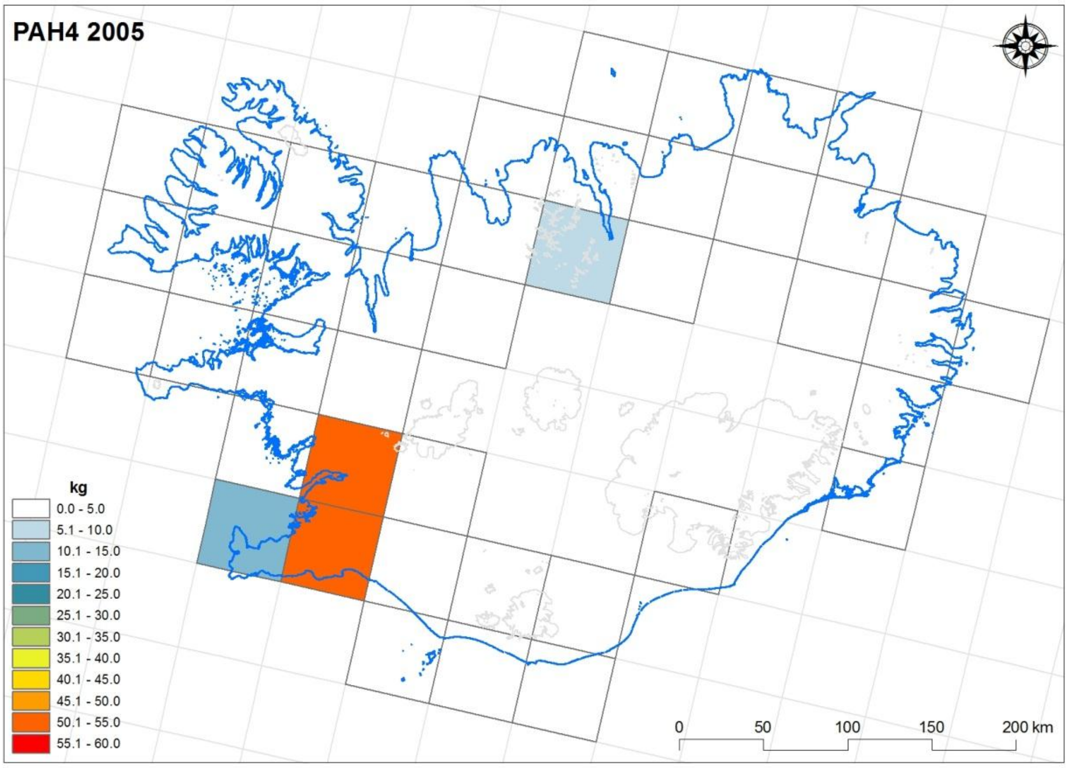

Figure 9.4. Emissions of PAH4 within the EMEP-Grid in 2005.

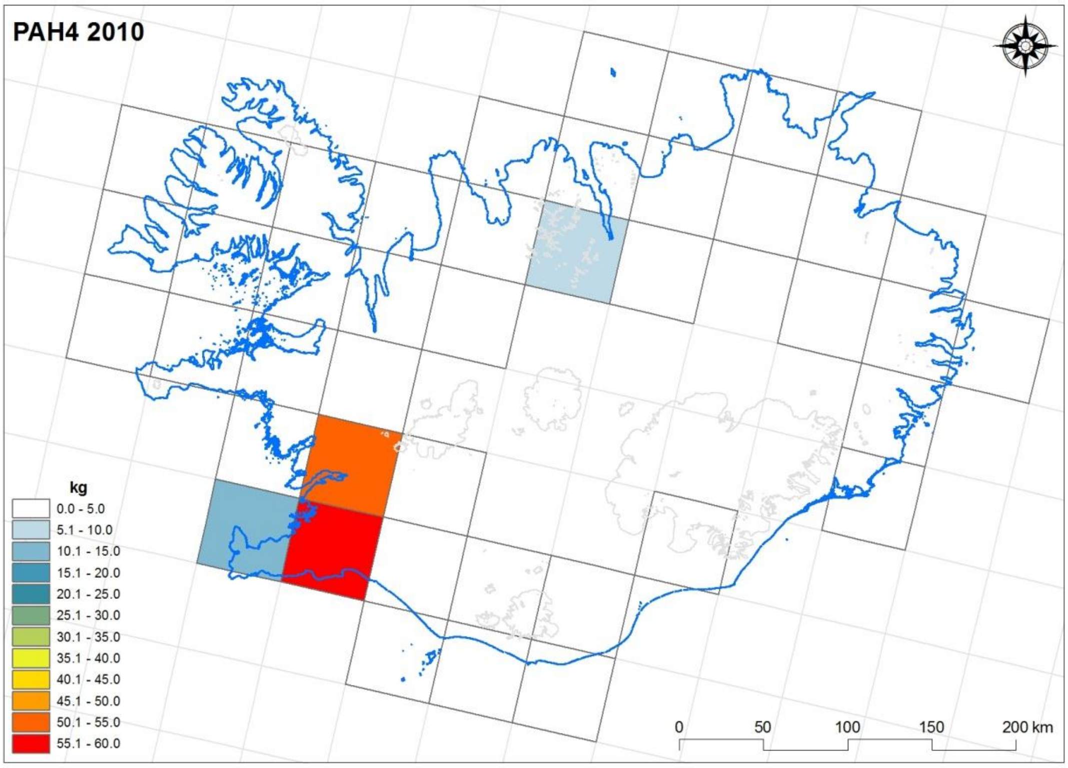

Figure 9.5. Emissions of PAH4 within the EMEP-Grid in 2010.

Figures 9.6 to 9.10 show the national total emissions of dioxin within the EMEP-Grid in 1990, 1995, 2000, 2005 and 2010.

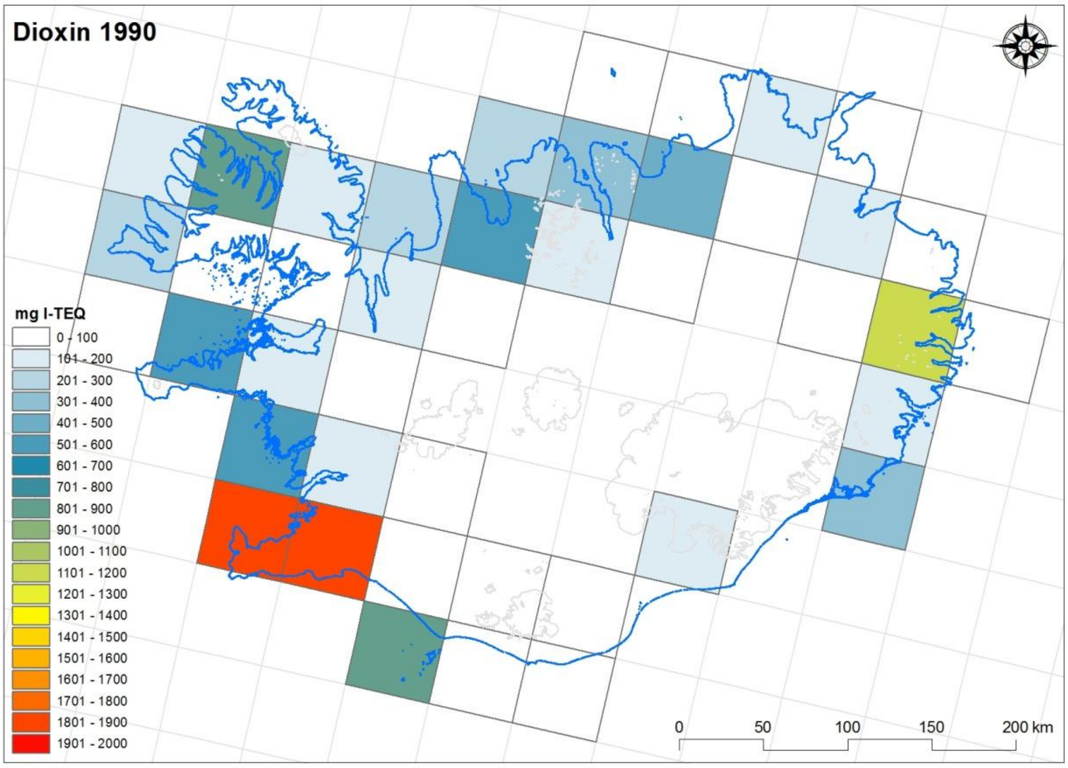

Figure 9.6. Emissions of dioxins within the EMEP-Grid in 1990.

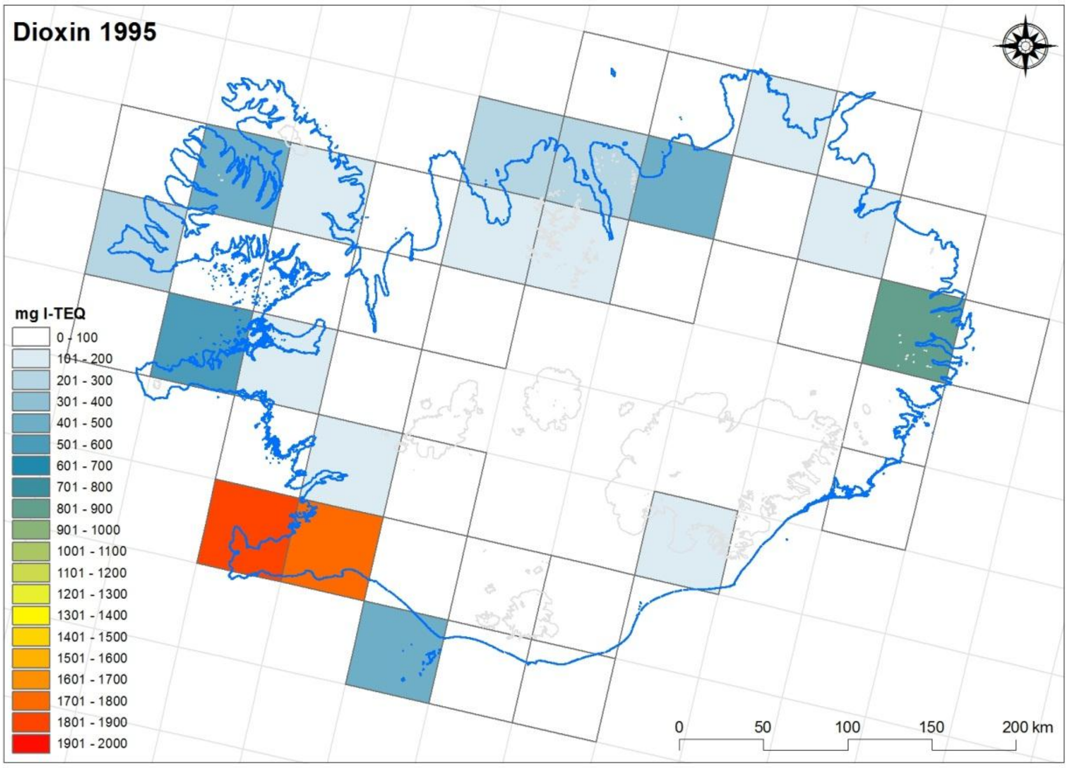

Figure 9.7. Emissions of dioxins within the EMEP-Grid in 1995.

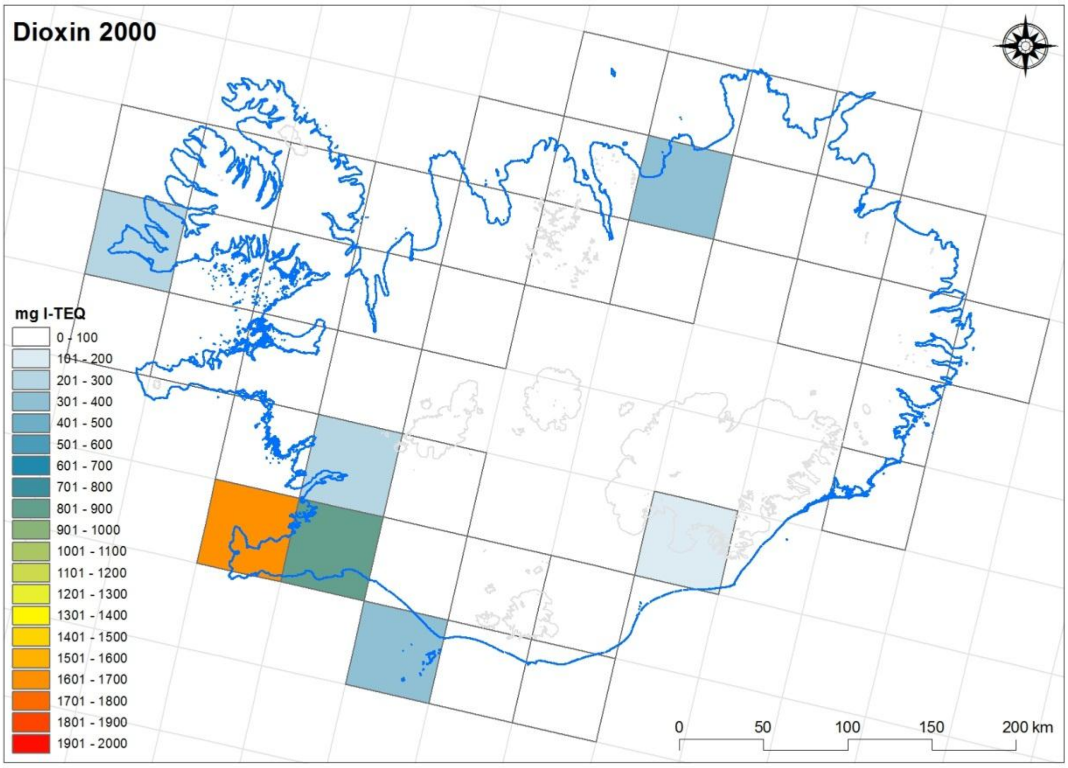

Figure 9.8. Emissions of dioxins within the EMEP-Grid in 2000.

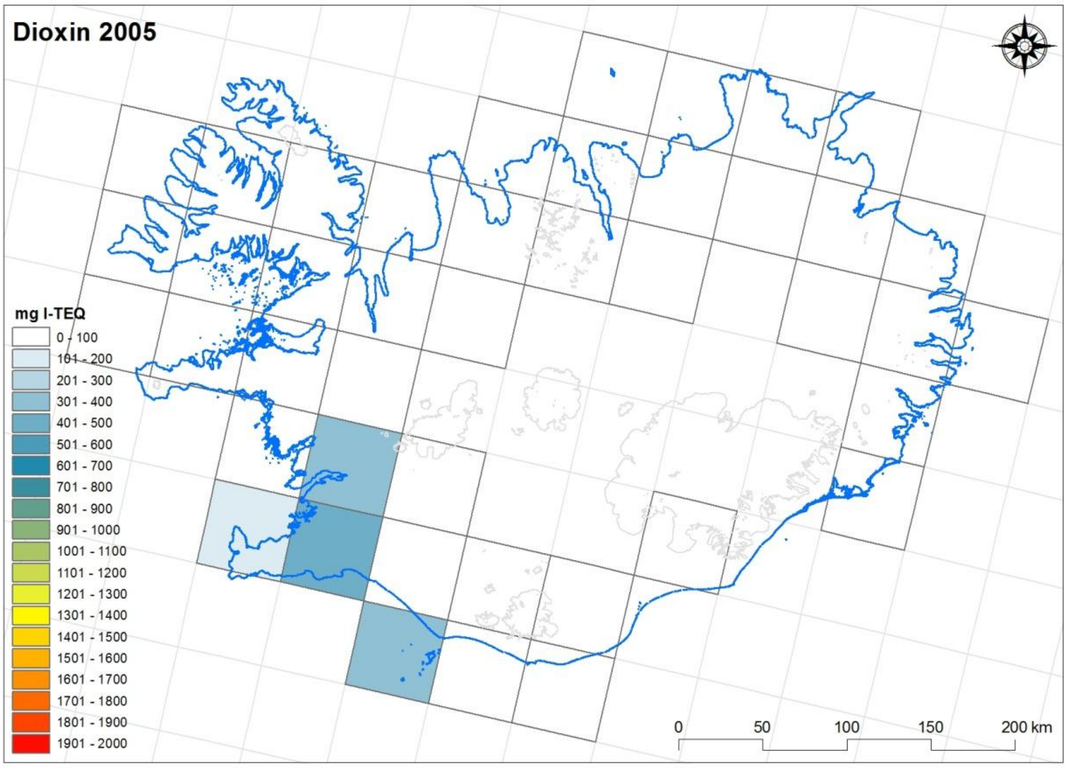

Figure 9.9. Emissions of dioxins within the EMEP-Grid in 2005.

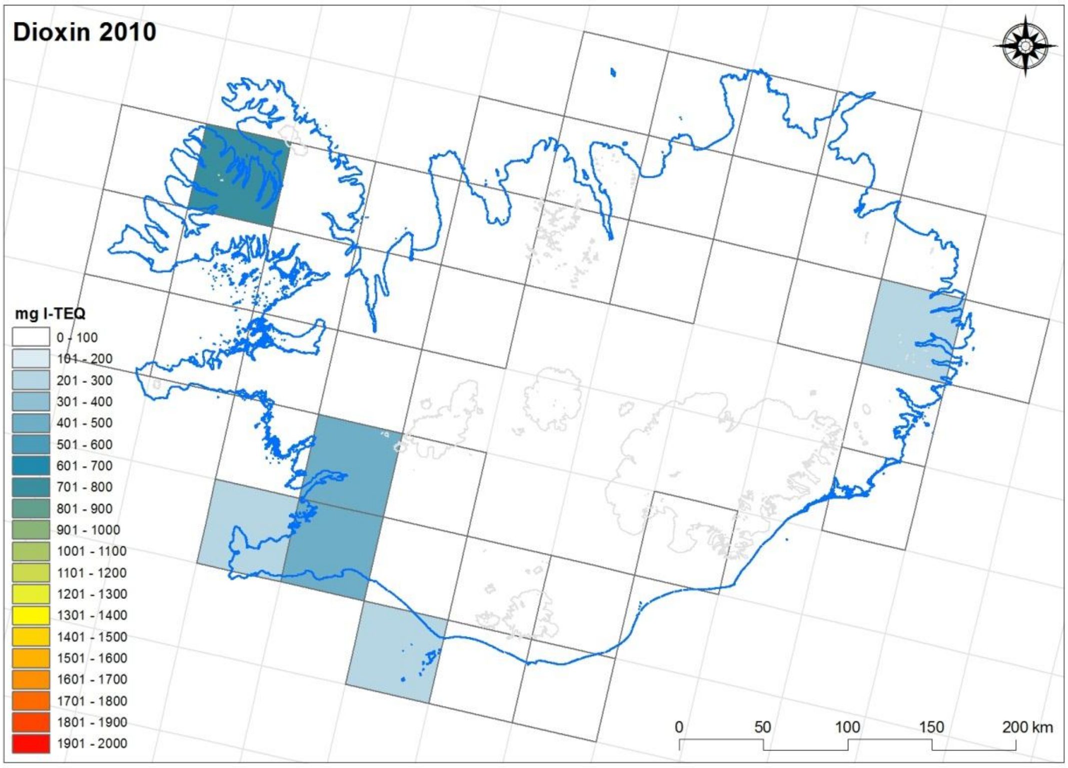

Figure 9.10. Emissions of dioxins within the EMEP-Grid in 2010.

For the distributed national totals, spatial patterns from the major sectors are recognisable. For PAH4 it can be seen how emissions in the areas with highest population density as well as the industrial sites become more over time. For dioxin the influence of closing down sites for open pit burning results in lower emissions over time. Further the malfunctioning of the incineration plant at Ísafjörður (north-west Iceland, Westfjords) results in higher emissions in 2010 than in the years before.

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ANNEX I EXPLANATION OF EA'S ADJUSTMENT OF DATA ON FUEL SALES BY SECTOR

Fuel sales (gas oil and residual fuel oil) by sectors 1A1a, 1A2 (stationary) and 1A4 (stationary) – as provided by the National Energy Authority

No.	Category	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
		Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Gas/Diesel Oil																	
10X40	house heating and swimming pools	8,535	10,511	7,559	9,797	10,034	7,625	6,349	5,756	3,665	4,428	4,240	2,417	2,420	1,546	1,626	1,637
10X5X	industry	1,129	1,998	2,500	5,803	8,093	8,920	9,443	10,233	22,762	24,995	15,196	15,455	12,819	7,217	9,100	6,663
10X60	energy industries	1,091	1,252	631	564	820	1,065	897	1,112	631	112	21	1,349	1,109	1,436	760	1,012
10X90	other	458	69	12	909	1,063	1,386	1,323	756	1,832	8,124	8,928	8,296	2,033	1,336	1,499	2,728
Residual Fuel Oil																	
10840	house heating and swmimming pools	3,079	1,749	701	661	236	122	162	203	118	37	195	76	86	63	78	0
1085X	industry	56,172	71,280	80,461	64,958	64,303	46,146	55,782	64,026	48,547	28,230	25,005	23,635	22,708	19,562	17,646	14,917
10860	energy industries	0	18	58	816	230	-53	0	23	0	0	0	5	4,498	0	0	0
10890	other	52	53	-4	669	319	67	4,978	6,465	319	6,139	0	0	45	913	0	1,629

ADJUSTMENTS
For gas oil:
First fuel consumption needed for the known electricity production with fuels is calculated(**1A1a** – electricity production), assuming 34% efficiency, The values calculated are compared with the fuel sales for the category 10X60 Energy industries.

- In years where there is less fuel sale to energy industries as would be needed for the electricity production, the fuel needed is taken from the categorie 10X90 Other and when that is not sufficient from the category 10X40 House heating and swimming pools.
- In years where there is surplus the extra fuel is added to the category 10X40 House heating and swimming pools.

NEA has estimated the fuel use by swimming pools (**1A4a**), These values are subtracted from the adjusted 10X40 category, The rest of the category is then **1A4b** – Residential.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Swimming pools	1,600	1,600	1,600	1,600	1,600	1,600	1,400	1,400	1,200	1,100	1,000	300	300	300	300	300

For years when there is still fuel in the category 10X90 Other, this is added to the 10X5X Industry, This is the fuel use in **1A2** – Industry.

For Residual Fuel Oil:
The sectors 10840 and 10860 are added together. This is the fuel use by **1A1a** - public heat plants, In year 1997 four tonnes are subtracted from this category as the category 10890 has minus four tonnes, leaving category 10890 with 0 in 1997.

The categories 1085X Industry and 10890 Other are added together, This is the fuel use in 1A2 – industry.