National Inventory Report

Iceland
2004

Preface

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 and entered into force in 1994. According to Articles 4 and 12 of the Convention, Parties are required to develop and to submit annually to the UNFCCC national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol.

To comply with this requirement, Iceland has prepared a National Inventory Report (NIR) for the year 2004. This is the first time Iceland delivers a NIR. The NIR together with the associated Common Reporting Format tables (CRF) is Iceland's contribution to this round of reporting under the Convention, and covers emissions and removals in the period 1990 – 2002. The report has been prepared in accordance with the UNFCCC Reporting Guidelines on Annual Inventories adopted in November 2002 by the Conference of the Parties to the Convention (Decision 18/CP.8). The methodologies used to calculate emissions and removals are in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the IPCC Good Practice Guidance and Uncertainty management in National Greenhouse Gas Inventories.

The Ministry for the Environment is responsible for the reporting. The Environmental and Food Agency of Iceland (EFA) and the Agricultural Research Institute (ARI) have been the principle contributors to the preparation of the report.

Ministry of the Environment, Reykjavík, July 2004

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Ministry for the Environment

EXECUTIVE SUMMARY

Kyoto accounting:

For 2002, Iceland's total greenhouse gas emissions were estimated to be 3.181 Gg CO_2-equivalents, excluding emissions falling under Decision 14/CP.7. Iceland's total emissions in 2002 were 4% below the 1990 levels. Iceland's net greenhouse gas emissions, including CO_2-removals with LUCF, were estimated to be 3.019 Gg CO_2-equivalents in 2002. Iceland's net emissions in 2002 were 9% below the 1990 levels.

Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) requires that the Parties report annually on their greenhouse gas emissions by sources and removals by sinks. In response to these requirements, Iceland has prepared the present National Inventory Report (NIR). This is the first time Iceland delivers a NIR.

Iceland is a party of the UNFCCC, and Iceland acceded to the Kyoto Protocol on May 23rd, 2002. Earlier that year the government adopted a new climate change policy that was formulated in close cooperation between several ministries. The aim of the policy is to curb emissions of greenhouse gases so that they will not exceed the limits of Iceland´s obligations under the Kyoto Protocol. A second objective is to increase the level of carbon sequestration resulting from reforestation and revegetation programs.

Iceland's National Greenhouse Gas Inventory Report 2004 has the dual purpose of providing estimates of Iceland's net greenhouse emissions for the United Nations Convention on Climate Change (UNFCCC) and of tracking Iceland's progress towards its internationally agreed target of limiting emissions to 110% of the 1990 levels over the period 2008-2012.

The IPCC Good Practice Guidelines, the Revised 1996 Guidelines and national estimation methods are used in producing the greenhouse gas emissions inventories. The Common Reporting Format (CRF) tables are used in reporting the emission figures. The responsibility of producing the emissions data is by the Environment and Food Agency, which is responsible for compiling and maintaining the greenhouse gas inventory. The CO_2 removals with LUCF are compiled by the Agricultural Research Institute. The national inventory and reporting system is constantly being developed and improved.

Trends in emissions and removals

In 1990, the total emissions of greenhouse gases in Iceland were 3.322 Gg of CO_2-equivalents. In 2002 total emissions were 3.181 Gg CO_2-equivalents, excluding emissions falling under Decision 14/CP.7. This is an decrease of 4% over the time period. On the other hand, when all emissions are included, the emissions from 1990 to 2002 have increased by 9%. Total emissions show a decrease between 1990 and 1994, with an exception in 1993, and an increase thereafter.

Summary of the Icelandic national emissions for 1990, 2001 and 2002 is presented in Table ES1 (without LUCF). Empty cells indicate emissions not occurring.

Table ES1. Emissions of greenhouse gases during the period 1990, 2001 and 2002, Gg CO_2-eq.

	1990	2001	2002	Changes 90-02	Changes 01-02
CO_2	2085,4	2185,7	2237,9	7%	2%
CH_4	460,8	540,5	526,8	14%	-3%
N_2O	350,7	335,5	303,5	-13%	-10%
HFC 32		0,0	0,0		30%
HFC 125		23,2	15,7		-32%
HFC 134a		6,8	3,8		-44%
HFC 143a		23,8	15,6		-34%
HFC 152		0,1	0,0		-32%
CF_4	355,0	77,5	61,4	-83%	-21%
C_2F_6	64,6	14,1	11,2	-83%	-21%
SF_6	5,4	5,4	5,4	0%	0%
Total	**3321,7**	**3212,4**	**3181,2**	**-4%**	**-1%**
CO_2 emissions fulfilling 14/CP.7		404,3	441,3		9%
Total emissions, including CO_2 emissions fulfilling 14/CP.7		**3616,8**	**3622,5**	**9%**	**0%**

The largest contributor of greenhouse gas emissions in Iceland is the energy sector, followed by agriculture, then industrial processes and waste. From 1990 to 2002 the contribution of the energy sector to the total net emissions increased from 51% to 63% respectively. At the same time the contribution from industrial processes decreased from 26% in 1990 to 16% in 2002. If all industrial process emissions in 2002 are included (also those emissions falling under Decision 14/CP.7) the contribution of industrial processes to total emissions and removals would be 27% in 2002.

Table ES2. Total emissions of greenhouse gases by sources and CO_2 removals from LUCF in 1990, 2001 and 2002, Gg CO_2-eq.

	1990	2001	2002
Energy	1703	1843	1915
Industrial Processes	865	565	493
Emissions fulfilling 14/CP.7*	-	404	441
Solvent Use	NE	NE	NE
Agriculture	568	524	503
LUCF	-6	-145	-163
Waste	185	280	269
Total without LUCF	**3322**	**3212**	**3181**
Total with LUCF	3316	3067	3019

* industrial process carbon dioxide emissions fulfilling Decision 14/CP.7 are not included in national totals

The distribution of the total greenhouse gas emissions (excluding emissions falling under Decision 14/CP.7) over the UNFCCC sectors in 2002 is shown in figure ES1. Emissions from the energy sector account for 61% of the national total emissions and agriculture and industrial processes account for 16 and 15% respectively. The waste sector accounts for 8% and solvent use is not estimated.

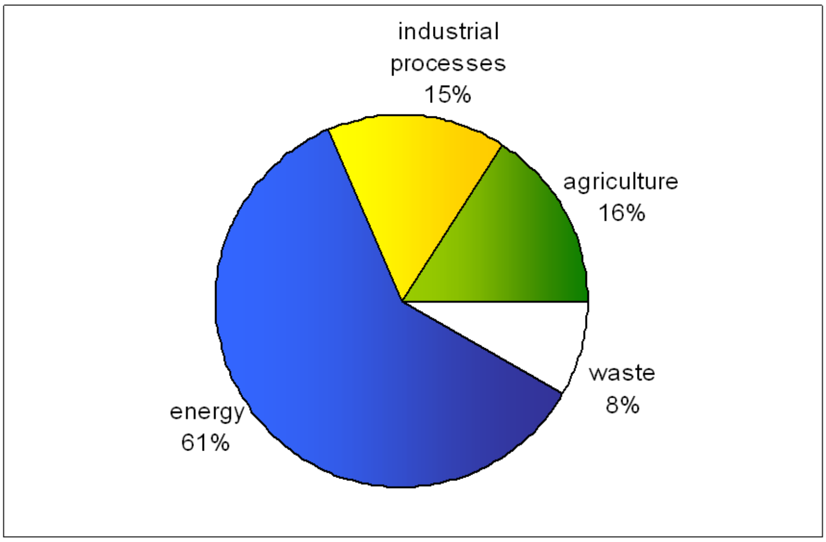


Figure ES1. Emissions of greenhouse gases by UNFCCC sector in 2002

1 INTRODUCTION

1.1 Background information

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) was ratified by Iceland in 1993 and entered into force in 1994. One of the requirements under the Convention is that Parties are to report their national anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using methodologies agreed upon by the Conference of the Parties to the Convention (COP).

In 1995 the Government of Iceland adopted an implementation strategy based on the commitments in the Framework Convention. The domestic implementation strategy was revised in 2002, based on the commitments in the Kyoto Protocol and the provisions of the Marrakech Accords. Iceland acceded to the Kyoto Protocol on May 23rd 2002. The Kyoto Protocol commits Annex I Parties to individual, legally binding targets for their greenhouse gas emissions in the "commitment period" 2008-2012. Iceland’s obligations according to the Kyoto Protocol are as follows:

- For the first commitment period, from 2008 to 2012, the greenhouse gas emissions shall not increase more than 10% from the level of emissions in 1990.
- For the first commitment period, from 2008 to 2012, the mean annual carbon dioxide emissions falling under decision 14/CP.7 on the “Impact of single project on emissions in the commitment period” shall not exceed 1,600,000 tons.

The Ministry for the Environment formulated the climate change policy in close collaboration with the ministries of Transport and Communications, Fisheries, Finance, Agriculture, Industry and Commerce, Foreign Affairs and the Prime Minister’s Office. The aim of the policy is to curb emissions of greenhouse gases so that they will not exceed the limits of Iceland´s obligations under the Kyoto Protocol. A second objective is to increase the level of carbon sequestration resulting from reforestation and revegetation programs. The climate change policy will be reviewed again in the year 2005.

The greenhouse gas emissions profile for Iceland is in many regards unusual. Three features stand out. First, emissions from the generation of electricity and from spatial heating are essentially non-existent since they are generated from renewable non-emitting energy sources. Second, more than 80% of emissions from energy come from mobile sources (transport, mobile machinery and fishing vessels). The third distinctive feature is that individual sources of industrial process emissions have a significant proportional impact on emissions at the national level. Most noticeable in this regard is abrupt increases in emissions from aluminum production associated with the expanded production capacity of this industry. This last aspect of Iceland’s emission profile made it difficult to set meaningful targets for Iceland during the Kyoto Protocol negotiations. This fact was acknowledged in Decision 1/CP.3 paragraph 5(d), which established a process for considering the issue and taking appropriate action. This process was completed with Decision 14/CP.7 on the Impact of Single Projects on Emissions in the Commitment Period.

The problem associated with the significant proportional impact of single projects on emissions is fundamentally a problem of scale. In small economies, single projects can dominate the changes in emissions from year to year. When the impact of such projects becomes several times larger than the combined effects of available greenhouse gas abatement measures, it becomes very difficult for the party involved to adopt quantified emissions limitations. It does not take a large source to strongly influence the total emissions from Iceland. A single aluminum plant can add more than 15% to the country's total greenhouse gas emissions. A plant of the same size would have negligible effect on emissions in most industrialized countries. Decision 14/CP.7 sets a threshold for significant proportional impact of single projects at 5% of total carbon dioxide emissions of a party in 1990. Projects exceeding this threshold shall be reported separately and carbon dioxide emissions from them not included in national totals to the extent that they would cause the party to exceed its assigned amount. Iceland can therefore not transfer assigned amount units to other Parties through international emissions trading. The total amount that can be reported separately under this decision is set at 1.6 million tons of carbon dioxide. The scope of Decision 14/CP.7 is explicitly limited to small economies, defined as economies emitting less than 0.05% of total Annex I carbon dioxide emissions in 1990. In addition to the criteria above, which relate to the fundamental problem of scale, additional criteria are included that relate to the nature of the project and the emission savings resulting from it. Only projects, where renewable energy is used, and where this use of renewable energy results in a reduction in greenhouse gas emissions per unit of production, will be eligible. The use of best environmental practice and best available technology is also required. It should be underlined that the decision only applies to carbon dioxide emissions from industrial processes. Other emissions, such as energy emissions or process emissions of other gases, such as PFCs, will not be affected.

Paragraph 4 of Decision 14/CP.7 requests any Party intending to avail itself of the provisions of that decision to notify the Conference of the Parties, prior to its eighth session, of its intention. The Government of Iceland notified the Conference of the Parties with a letter, dated October 17th 2002 of its intention to avail itself of the provisions of Decision 14/CP.7. Decision 14/CP.7 further requests any Party with projects meeting the requirements specified in the Decision, to report emission factors, total process emissions from these projects, and an estimate of the emission savings resulting from the use of renewable energy in these projects in their annual inventory submissions. The secretariat is requested to compile information submitted by Parties in accordance with the above request, to provide comparisons with relevant emission factors reported by other Parties, and to report this information to the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol. Iceland has already initiated preparations for the implementation of these special reporting provisions. One part of these changes in reporting was first reflected in the inventory report for the year 2000 submitted in April 2002. This inventory was presented as called for in Decision 14/CP.7. This was done to facilitate evaluation of the emission trends in Iceland and the policies and measures being implemented or planned. It was considered more consistent with the intent of 14/CP.7 to use this approach to reporting also for the period leading up to the commitment period rather than to introduce an abrupt change in the reporting approach in 2008. In the report for the year 2002 submitted in June 2002 three projects fall under the single project definition and are reported in accordance to Decision 14/CP.7.

The present report together with the associated Common Reporting Format tables (CRF) is Icelands contribution to this round of reporting under the Convention, and covers emissions and removals in the period 1990 – 2002. It has been prepared in accordance with the UNFCCC Reporting Guidelines on Annual Inventories adopted by the COP by its Decision 18/CP.8. The methodology used in calculating the emissions is according to the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories as set out by the IPCC Good Practice Guidance, to the extend possible.

The greenhouse gases included in the national inventory are the following: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hyudrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluorid (SF_6). Emissions of the precursors NOx, NMVOC and CO as well as SO_2 are also included, in compliance with the reporting guidelines.

This is the first time Iceland submits an National Inventory Report. During the last year the Icelandic emissions inventory has changed substantially. Most of these changes were done in response to the desk review of the greenhouse gas inventory that Iceland submitted in 2001, and were published by the Secretariat on March 12th 2003. The main changes are:

Energy:
- Different classification of fuel consumption between sectors (Residential vs Energy Industries, diesel fuel consumption of equipment was replaced from the Transport sector to the Manufacturing Industries and Construction sector, CO_2 emissions from waste incineration with energy recovery replaced from the Waste Sector to Public Energy and Heat Production).

Industrial processes:
- Method for estimating PFC´s emissions from the Aluminium industry was upgrated from a country specific method to Tier 2 method.

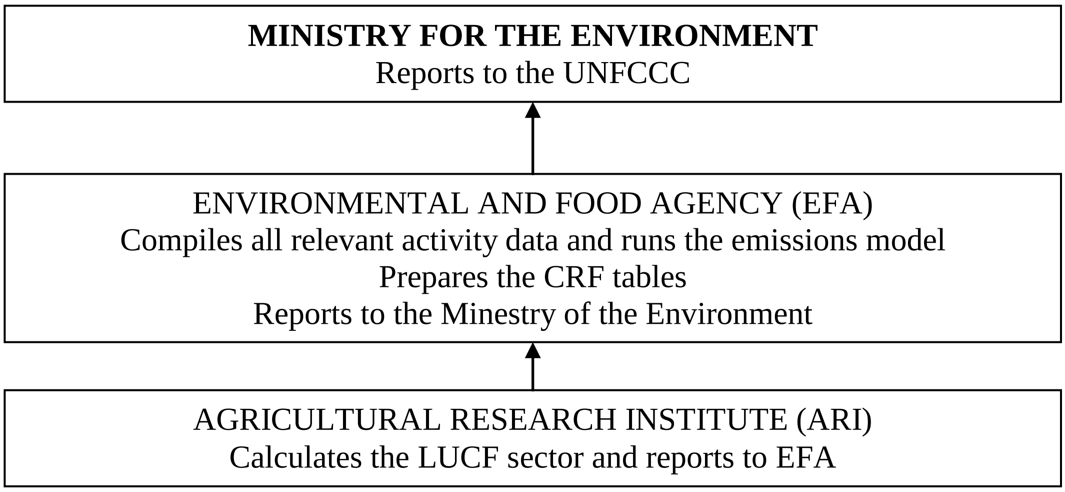
Agriculture:
- Methods and emission factors for estimating N_2O were adjusted to the IPCC Guidelines
- Figures for number of animals were revised
- Inclusion of sources not estimated before (indirect soil emissions, emissions from grazing animals)

Waste:
- Methods and emission factors for estimating methane from solid waste disposal on land were adjusted to IPCC Guidelines
- Figures for landfilled wastes were revised.
- Methods and emission factors for estimating CO_2 emissions from waste incineration were adjusted to IPCC Guidelines.

These changes have resulted in higher emissions than previously estimated. In comparison with data submitted in 2003, the total emissions estimated in this submission are around 14-19% higher for each year from 1990 to 2001. A more detailed clarification regarding these changes will be made under the relevant sector in the report.

1.2 Institutional arrangement

The Environmental and Food Agency of Iceland (EFA) compiles and maintaines the greenhouse gas emission inventory, except LUCF which is compiled by the Agricultural Research Institute (ARI). EFA reports to the Ministry for the Environment, which reports to the Convention.



A formal procedure on the cooperation between the Minestry of the Environment on the one hand and the EFA and ARI on the other hand has not yet been established.

1.3 Process of inventory preparation

EFA collects the bulk of data necessary to run the general emission model, i.e. activity data and emission factors.

1.4 Methodologies and used data sources

The estimation methods of all greenhouse gases are harmonised with the current IPCC Guidelines for National Greenhouse Gas Inventories and are, to the extent possible, in accordance with IPCC's Good Partice Guidance. Statistics on waste and import of ssubstitutes for ozone depleting substances (HFC´s) are collected directly by EFA. Information on import of fuels, use of synthetic fertilizers (Nitrogen) and solvents are collected from Statistics Iceland. The National Energy Authority provides data on fuel sales by sector. The industry provides data on production, use of fuels and feedstock as well as process specific information. Data on livestock statistics are collected from the Icelandic Association of Farmers. Few emission measurement exist in Iceland. Emission factors are thus mainly taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

1.5 Key source categories

According to the IPCC definition, key sources are those that add up to 90% of the total uncertainty in level and/or in trend. In the Icelandic Emission Inventory key source categories are identified by means of Tier 1 method.

A key source analysis was prepared for this round of reporting. The table below lists identified key sources. Tables showing key source analysis (trend and level assessment) can be found in Annex I.

Table 1.1 Key sources

IPCC SOURCE CATEGORIES	Direct GHG	Keysource	
		Level	Trend
ENERGY SECTOR			
Mobile combustion: fishing	CO_2	ν	ν
Mobile combustion: road vehicles	CO_2	ν	ν
Mobile combustion: road vehicles	N_2O		ν
Mobile combustion: construction industry	CO_2	ν	ν
CO_2 emissions from stationary combustion, oil	CO_2	ν	ν
CO_2 emissions from stationary combustion, coal	CO_2		ν
INDUSTRIAL PROCESSES			
CO_2 emissions from Ferroalloys	CO_2	ν	
CO_2 emissions from cement production	CO_2	ν	
CO_2 emissions from aluminium production	CO_2	ν	
PFC emissions from aluminium production	PFC	ν	ν
Emissions from substitutes for Ozone Depleting Substances	HFC	ν	ν
AGRICULTURE			
CH_4 emissions from enteric fermentation	CH_4	ν	ν
Direct N_2O emissions from agricultural soils	N_2O	ν	ν
Indirect N_2O emissions from Nitrogen used in agriculture	N_2O	ν	
WASTE			
CH_4 emissions from solid waste disposal sites	CH_4	ν	ν
Emissions from waste incineration	CO_2		ν

1.6 Quality assurance and quality control (QA/QC)

No formal QA/QC plan exists yet. Calculations and units have though been checked internally within the EFA. Also data consistency between years is checked.

1.7 Uncertainty evaluation

The quantitative uncertainty of the Icelandic emission inventory has not been evaluated yet. This is a priority before the next submission. A qualitative uncertainty assessment can be found in the CRF tables.

1.8 General assessment of the completeness

An assessment of the completeness of the emission inventory should according to the IPCC´s Good Practice Guidance address the issues of spatial, temporal and sectoral coverage along with all underlying source categories and activities.

In terms of spatial coverage, the emission reported under the UNFCCC covers all activities within Iceland’s jurisdiction.

In the case of temporal coverage, CRF tables are reported for the whole time series from 1990 to 2002.

With regard to sectoral coverage few sources are not estimated. They are listed in table 9 of the CRF.

The main sources not estimated are:

- Emissions of N_2O from fuel combustion in the mineral industry (1A2f) and emissions of CH_4 and N_2O from fuel combustion in other industry (1A2f)
- Emissions of CH_4 and N_2O from commercial/institutional and residential fuel combustion (1A4a, 1A4b)
- Emissions of CH_4 and N_2O from other fuel combustion (1A5)
- Emissions of CH_4 and N_2O from the industrial processes by the mineral wool production (2A7)
- Only the potential emissions of HFCs are estimated and SF_6 emissions are not estimated but held constant over the whole time series (2F)
- Emissions of N_2O and CH_4 from wastewater handling (6B)
- Emissions and removals of CO_2, CH_4 and N_2O from Forest and Grassland Conversion
- Emissions and removals of CO_2, CH_4 and N_2O from Abandonment of Managed Land
- Emissions and removals of CO_2 from Soil

The reason for not including the above activities/gases in the present submission is lack of data and/or further work has not been possible due to time constraints in the preperation of the emission inventory.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Emission trends for aggregated greenhouse gas emissions

The total amount of greenhouse gases emitted in Iceland during the period 1990 – 2002 is presented in the following tables, expressed in terms of contribution by gases and by sources. Emissions falling under Decision 14/CP.7 are not included in this discussion unless specifically noted.

Table 2.1 below presents emission figures for all direct greenhouse gases, expressed in CO_2-equivalents along with the percentage change indicated for both the time period 1990 – 2002 and 2001 – 2002.

Table 2.1. Emissions of greenhouse gases in Iceland during the period 1990 – 2002 (without LUCF). Empty cells indicate emissions not occurring. Units: Gg CO_2-eq

	Year													Change	
Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	90-02	01-02
CO_2	2085,4	2003,3	2125,6	2232,2	2196,5	2213,3	2302,1	2405,4	2286,7	2454,7	2306,2	2185,7	2237,9	7%	2%
CH_4	460,8	462,9	462,0	468,5	475,3	479,4	493,2	509,4	523,2	520,3	539,7	540,5	526,8	14%	-3%
N_2O	350,7	342,5	321,1	329,2	334,7	331,4	349,3	348,2	346,2	366,0	341,6	335,5	303,5	-13%	-10%
HFC 32									0,0	0,0	0,1	0,0	0,0		30%
HFC 125						10,8	11,7	11,1	27,1	23,5	14,5	23,2	15,7		-32%
HFC 134a			0,5	1,6	3,1	4,1	6,5	7,1	8,0	8,2	6,0	6,8	3,8		-44%
HFC 143a						10,0	10,3	19,0	28,6	27,6	11,6	23,8	15,6		-34%
HFC 152a						0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,0		-32%
CF_4	355,0	294,7	131,4	63,3	37,7	49,8	21,3	69,7	152,4	146,5	107,6	77,5	61,4	-83%	-21%
C_2F_6	64,6	53,6	23,9	11,5	6,9	9,1	3,9	12,7	27,7	26,7	19,6	14,1	11,2	-83%	-21%
SF_6	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	5,4	0%	0%
Total	**3321,7**	**3162,5**	**3069,8**	**3111,7**	**3059,5**	**3113,3**	**3203,8**	**3388,2**	**3405,6**	**3578,9**	**3352,2**	**3212,4**	**3181,2**	**-4%**	**-1%**
CO2 emissions fulfilling 14/CP.7									107,7	115,1	272,8	404,3	441,3		9%
Total emissions including CO2 emissions fulfilling 14/CP.7									**3513,3**	**3694,0**	**3625,1**	**3616,8**	**3622,5**	**9%**	**0%**

In 1990, the total emissions of greenhouse gases in Iceland were 3.322 Gg of CO_2-equivalents. In 2002 total emissions were 3.181 Gg CO_2-equivalents, excluding emissions falling under Decision 14/CP.7. This is an decrease of 4% over the time period. On the other hand, when all emissions are included, the emissions from 1990 to 2002 have increased by 9%. Total emissions show a decrease between 1990 and 1994, with an exception in 1993, and an increase thereafter. So far, 1999 has been the year with the highest emissions recorded.

Iceland has experienced economic growth since 1990, which explains the general growth in emissions. This has resulted in higher emissions from most sources, but in particular from transport and industrial processes. Since 1990 the number of private cars has been increasing much faster than the population. Also passengers using the public transport system has declined. More traffic is thus not mainly due to population growth, but much rather since a larger share of the population owns and uses private cars for their daily travel. During the late nineties large-scale industry expanded in Iceland. The existing aluminium plant and the ferroallyos industry experienced enlargement in 1997 and 1999, and in 1998 a new aluminium plant was established. As mentioned before industrial process carbon dioxide emissions from a single project falling under decision 14/CP.7 are to be reported separately and are not included in national totals. Today three projects fall under the single project definition and are reported in accordance to Decision 14/CP.7

Methane emissions have increased from 1990 to 2002 mainly due to increasing amount of waste going to managed landfills. Nitrous oxide emissions have on the other hand decreased since 1990, despite the fact that nitrous oxide emissions from road transport have increased. This is due to an decrease in animal livestock and because fertilizer production in Iceland was terminated in 2001.

Before 1992 there were no imports of HFCs, but since then, imports have increased rapidly in response to the phase-out of CFCs and HCFCs. The potential emissions of HFCs have risen from 0,5 Gg CO_2-equivalent in 1990 to 35,2 Gg CO_2-equivalent in 2002.

The overall increasing trend of greenhouse gas emissions has to some extend been counteracted by decreased emissions of PFCs, caused by improved technology and process control in the aluminium industry.

The overall emissions and removals of greenhouse gases have declined by 9% when emissions falling under Decision 14/CP.7 are excluded. This means that the net greenhouse gas emissions are within the Kyoto target set for Iceland.

2.2 Emission trends by gas

As shown in figure 2.1, CO_2 is by far the largest contributor (69%) to the total GHG emissions, followed by CH_4 (17%) and N_2O (10%) and then by fluorinated gases PFC, HFCs and SF_6 (4%). In 1990 the share of fluorinated gases was higher (13%), the share of CH_4 and N_2O about the same and the share of CO_2 lower (62%) than in 2002.

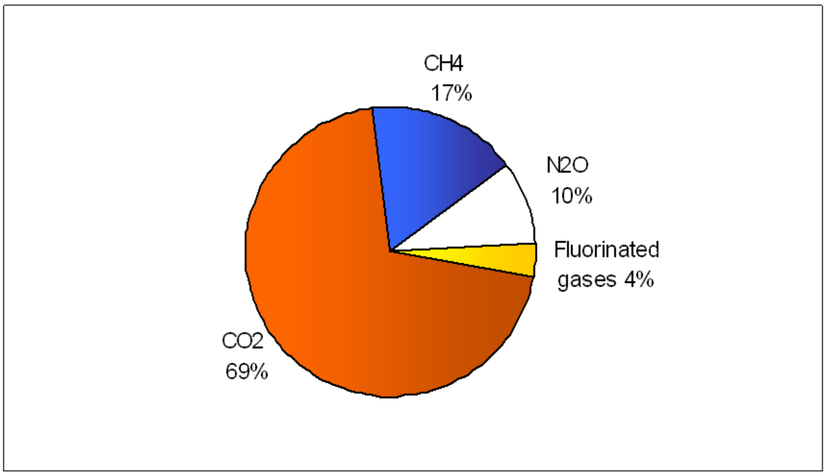


Figure 2.1 Distribution of emissions of greenhouse gases by gas, 2002

Figure 2.2 illustrates the percentage change in emissions of greenhouse gases by gas in Iceland from 1990 to 2002, compared to 1990.

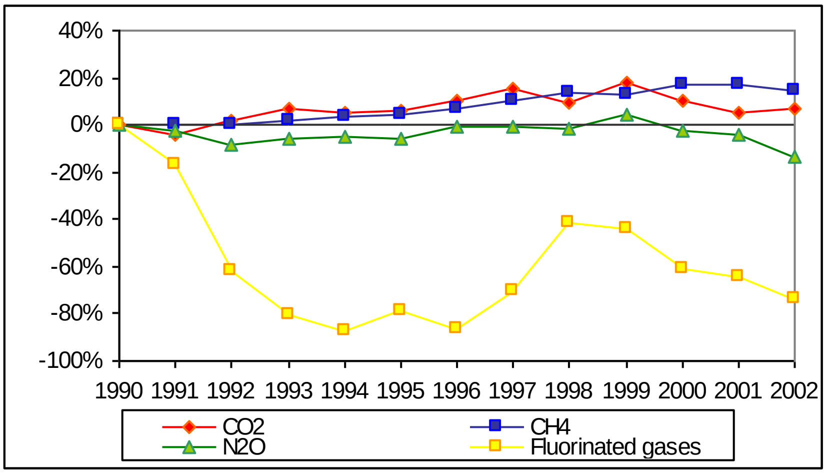


Figure 2.2 Percentage changes in emissions of greenhouse gases by gas 1990 – 2002, compared to 1990

2.2.1 Carbon dioxide (CO_2)

Fisheries, road transport and industrial processes are the three main sources of CO_2 emissions in Iceland. Since emissions from the generation of electricity and from spatial heating are essentially non-existent because they are generated from renewable non-emitting energy sources, emissions from stationary combustion are dominated by industrial sources. Thereof the fishmeal industry is by far the largest user of fossil fuels. Other sources consist mainly of emissions from the construction industry. Table 2.2 lists CO_2 emissions from each source category for the period 1990 – 2002. Figure 2.4 illustrates the distribution of CO_2 emissions by main source categories and figure 2.5 the percentage change in emissions of CO_2 by source from 1990 to 2002, compared to 1990.

Table 2.2 Emissions of CO_2 by sector 1990 – 2002, Gg.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fishing	655,5	675,5	739,7	770,3	759,4	771,8	828,4	809,7	780,8	765,3	720,0	639,5	705,2
Road vehicles	509,0	526,6	540,2	537,1	544,4	533,9	513,9	544,6	552,0	577,2	589,1	595,3	603,8
Stationary combustion, oil	237,0	168,3	241,0	252,9	228,9	218,7	269,6	284,6	261,5	264,4	203,3	245,2	274,7
Industrial processes	391,8	358,6	361,8	409,2	409,7	425,9	425,1	483,7	403,7	542,8	491,6	398,0	379,7
Other	292,1	274,3	242,9	262,8	254,0	263,1	265,2	282,9	288,8	304,9	302,2	307,7	274,4
Total	2085	2003	2126	2232	2196	2213	2302	2405	2287	2455	2306	2186	2238

In 2002 the total CO_2 emissions in Iceland, excluding emissions falling under Decision 14/CP.7 were 2.238 Gg. This is an increase of about 2% from the preceding year and of about 7% from 1990. This increase in emissions, between 2001 and 2002 can be explained by increased emissions from fisheries (10%) and from stationary combustion (12%, which are as mentioned above mainly due to the fishmeal industry and thus related to the increased emissions from fisheries). The increase in emissions between 1990 and 2002 can be explained by increased emissions from fisheries (8%) and stationary combustion (16%) as well as by increased emissions from road transport (19%). In the 1990s the vehicle fleet in Iceland almost doubled. Emissions from other sources as well as industrial processes have declined from 1990 to 2002, as well as from 2001 to 2002. On the other hand if emissions falling under Decision 14/CP.7 are included then CO_2 emissions from industrial processes would have increased by 110% from 1990 to 2002.

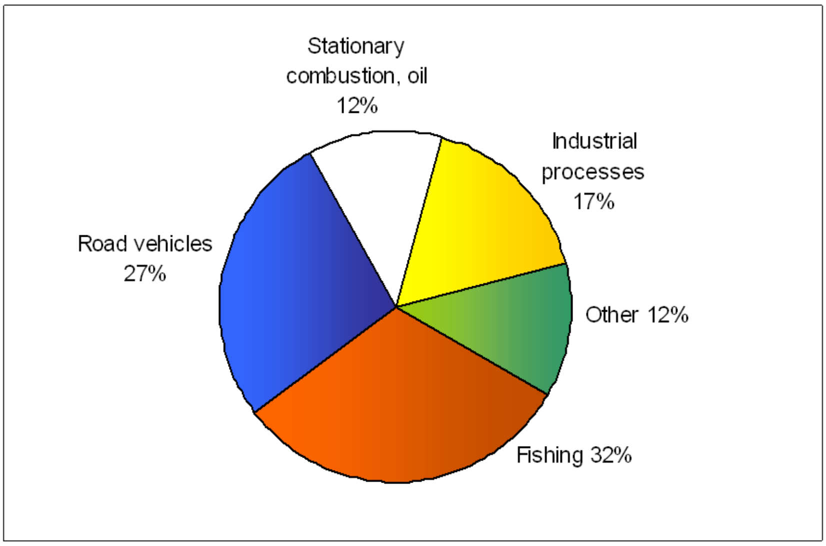


Figure 2.3 Distribution of CO_2 emissions by source in 2002

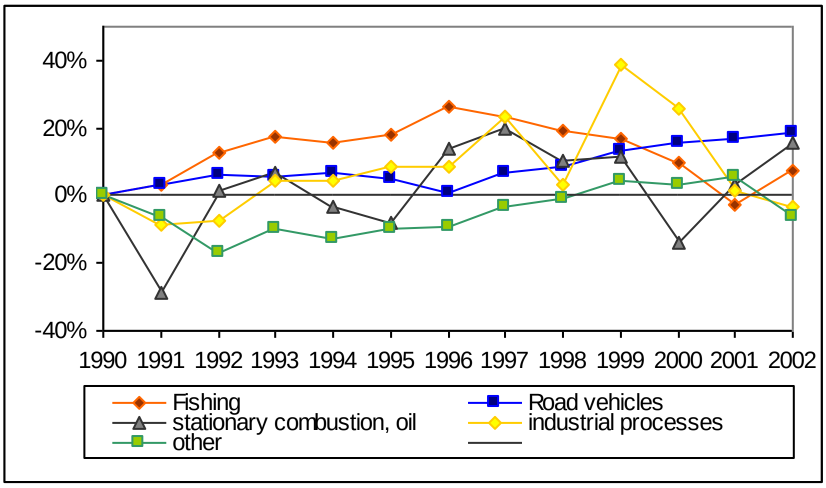


Figure 2.4 Percentage changes in emissions of CO_2 by major sources 1990 – 2002, compared to 1990

2.2.2 Methane (CH_4)

As can be seen from table 2.3 and figure 2.5, about 49 and 50% of the emissions of methane in 2002 originated from waste treatment and agriculture respectively. The emissions from agriculture are relatively stable from year to year, but the emissions from waste treatment show a steady increase from 1990 to 2001. This is due to increased amount of waste generated and increased ratio of landfilled wastes going to managed waste disposal sites. The emissions from landfills show a slight decrease from 2001 to 2002, due to increasing amount of methane recovery.

In the same way the overall emissions of methane show a slight increase every year from 1990 to 2001 and an slight decrease from 2001 to 2002.

Table 2.3 Emissions of CH_4 by sector 1990 – 2002, ktonnes

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Agriculture	13,9	13,6	13,2	13,1	13,2	12,8	12,9	13,1	13,3	13,1	12,6	12,5	12,3
Landfills	7,8	8,2	8,5	8,9	9,2	9,8	10,3	11,0	11,5	11,5	13,0	13,1	12,6
Other	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Total	21,9	22,1	22,0	22,3	22,6	22,8	23,5	24,3	24,9	24,8	25,7	25,8	25,1

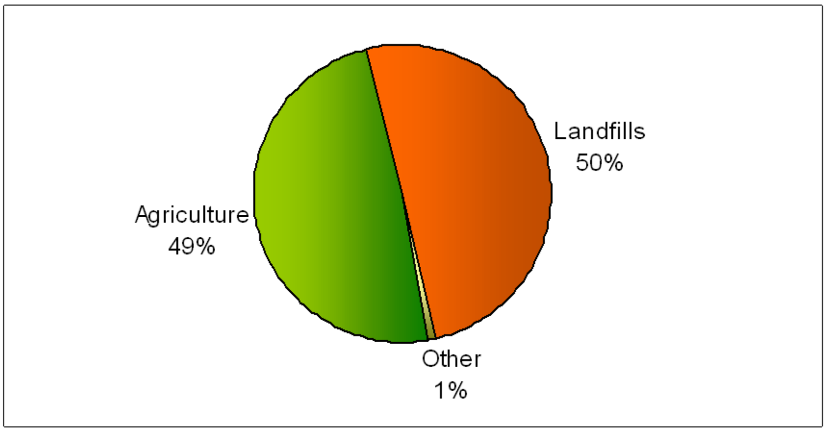


Figure 2.5 Distribution of CH_4 emissions by source in 2002

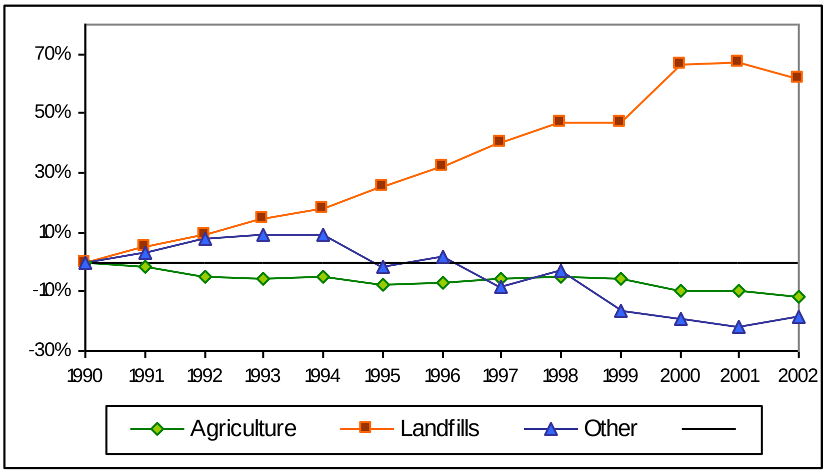


Figure 2.6 Percentage changes in emissions of CH_4 by major sources 1990 – 2002, compared to 1990

2.2.3 Nitrous oxide (N_2O)

As can be seen from table 2.4 and figure 2.7 agriculture accounts for around 80% of N_2O emissions in Iceland, with agricultural soils as the most prominent contributor. The second most important source is road transport, which has been increasing rapidly since the use of catalytic converters in all new vehicles became obligatory in 1995.

The overall nitrous oxide emissions decreased by 13% from 1990 to 2002. This is due to a decrease in the number of animal livestock and because fertilizer production in Iceland was terminated in 2001.

Table 2.4 Emissions of N_2O by sector 1990 – 2002, ktonnes

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Agriculture	0,9	0,9	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,9	0,9	0,8	0,8
Road traffic	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1
Other	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,1	0,1
Total	1,1	1,1	1,0	1,1	1,1	1,1	1,1	1,1	1,1	1,2	1,1	1,1	1,0

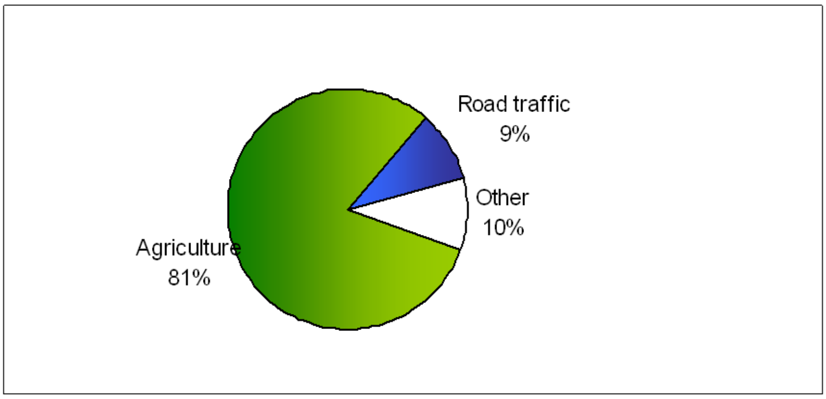


Figure 2.7 Distribution of N_2O emissions by source in 2002

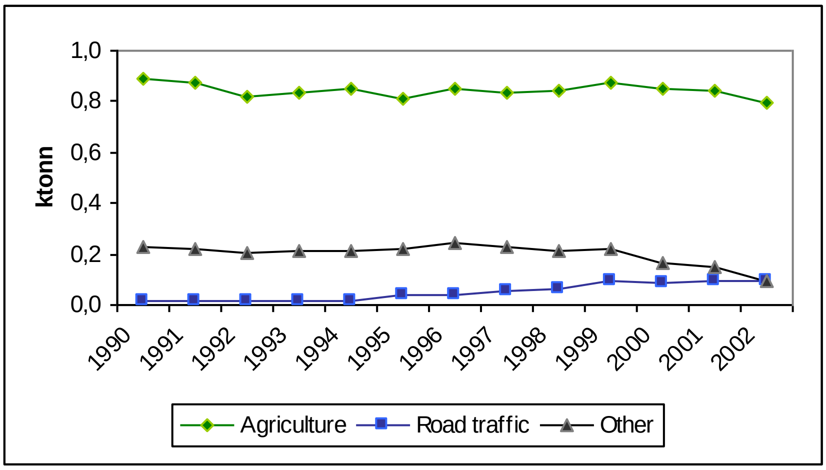


Figure 2.8 Changes in N_2O emission for major sources between 1990 and 2002

2.2.4 Perfluorcarbons

The emissions of the perfluorcarbons tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) from the aluminium plants in 2002 were 61,4 and 11,2 Gg CO_2-equivalents respectively.

The total emissions of PFCs decreased by 83% in the period of 1990 – 2002. As can be seen from figure 2.9 the emissions decreased steadily from 1990 to 1996 with the exception of 1995. In 1997 and 1998 the emissions increase again due to enlargement of the existing aluminium plant in 1997 and the establishment of a new aluminium plant in 1998. Since 1998 the emissions show again a steady downward trend. PFCs reduction is caused by improved technology and process control, which has led to a 94% decrease in the amount of PFCs emitted per tonne of aluminium produced during the period of 1990 – 2002.

Table 2.5 Emissions of PFCs by species 1990 – 2002, Gg CO_2-equivalent

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CF_4	357,5	294,7	131,4	63,3	37,7	49,8	21,3	69,7	152,4	146,5	107,6	77,5	61,4
C_2F_6	65,1	53,6	23,9	11,5	6,9	9,1	3,9	12,7	27,7	26,7	19,6	14,1	11,2
Total	422,6	348,3	155,3	74,9	44,6	58,8	25,1	82,4	180,1	173,2	127,2	91,7	72,5

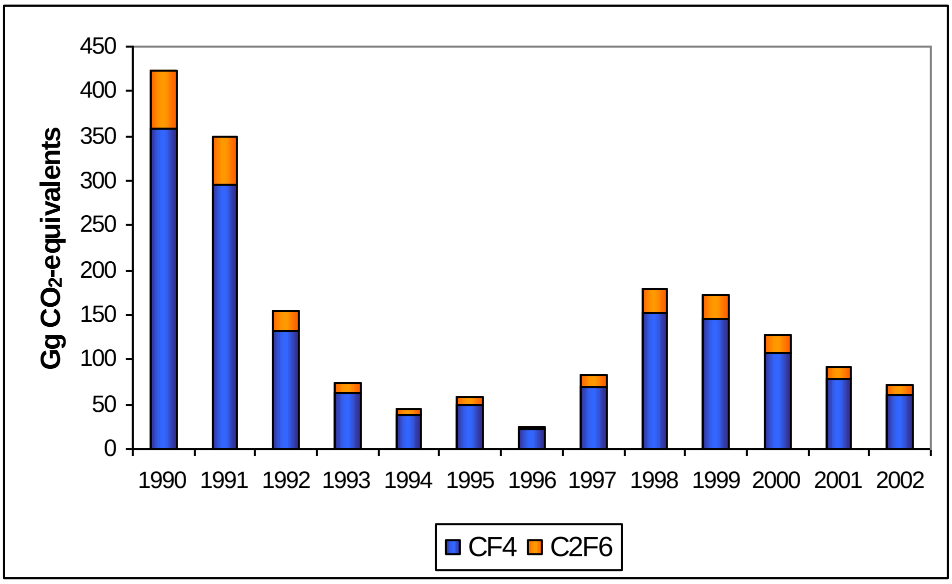


Figure 2.9 Emissions of PFCs from 1990 to 2002, Gg CO_2-equivalent

2.2.5 Hydro fluorocarbons (HFCs)

The total potential emissions of HFCs used as substitutes for ozone depleting substances amounted to 35,2 Gg CO_2-equivalents in 2002. The import of HFCs started in 1992 and increased until 1998. Since then annual imports have been between 30 and 60 Gg CO_2-equivalents. Sufficient data are not available to calculate actual emissions. This means that only potential emissions based on imports are estimated. The potential method is likely to overstate emissions, since chemicals used e.g. in refrigerators are emitted over a period of several years. The application category refrigeration contributes by far the largest part of HFCs emissions but foam blowing is also thought to be a minor source.

Table 2.6 Emissions of HFCs by species 1990 – 2002, Gg CO_2-equivalent

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
HFC 32	-	-	-	-	-	-	-	-	0,0	0,0	0,1	0,0	0,0
HFC 125	-	-	-	-	-	10,8	11,7	11,1	27,1	23,5	14,5	23,2	15,7
HFC 134a	-	-	0,5	1,6	3,1	4,1	6,5	7,1	8,0	8,2	6,0	6,8	3,8
HFC 143a	-	-	-	-	-	10,0	10,3	19,0	28,6	27,6	11,6	23,8	15,6
HFC 152a	-	-	-	-	-	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,0
Total	-	-	0,5	1,6	3,1	25,0	28,6	37,5	63,9	59,4	32,3	53,8	35,2

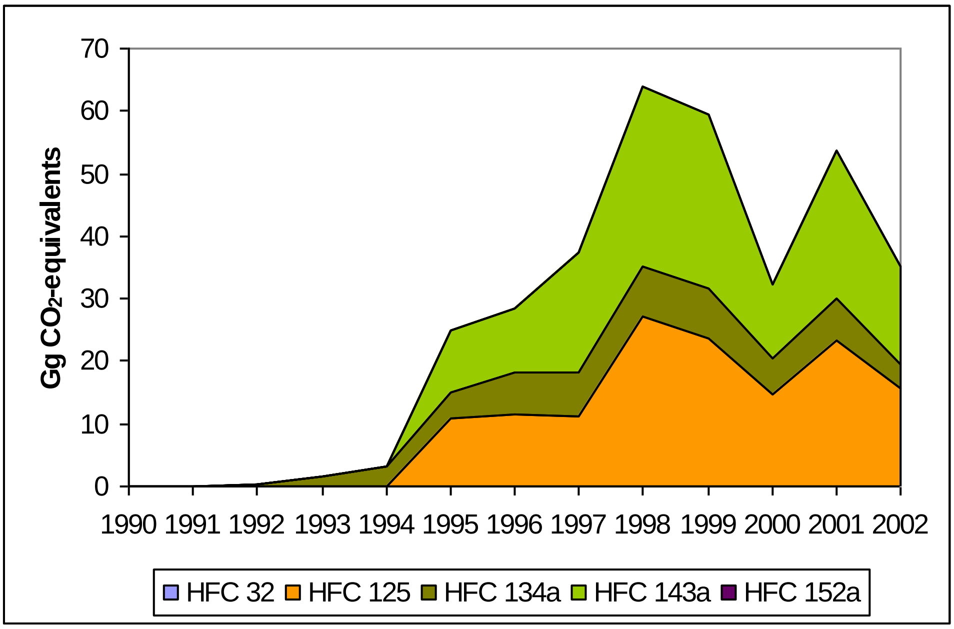


Figure 2.10 Potential emissions of HFCs by species 1990 – 2002, Gg CO_2-eq

2.2.6 Sulphur hexafluorid (SF_6)

Sulphur hexafluorid emissions are not estimated but held constant over the whole time series. The largest source of SF_6 emissions is thought to be leakages from electrical equipment.

2.3 Emission trends by source

The largest contributor of greenhouse gas emissions in Iceland is the energy sector, followed by agriculture, then industrial processes and waste. From 1990 to 2002 the contribution of the energy sector to the total net emissions increased from 51% to 63% respectively. At the same time the contribution from industrial processes decreased from 26% in 1990 to 16% in 2002. If all industrial process emissions in 2002 are included (also those emissions falling under Decision 14/CP.7) the contribution of industrial processes to total emissions and removals would be 27% in 2002.

Table 2.7 Total emissions of greenhouse gases by sources and CO_2 removals from LUCF in Iceland 1990 – 2002, Gg CO_2-equivalents

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Energy	1703	1657	1781	1842	1806	1816	1909	1965	1928	1968	1871	1843	1915
Industrial Processes	865	759	565	535	507	557	533	650	689	817	675	565	493
Emissions fulfilling 14/CP.7*	-	-	-	-	-	-	-	-	108	115	273	404	441
Solvent Use	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Agriculture	568	557	532	534	541	521	534	534	541	546	527	524	503
LUCF	-6	-15	-25	-37	-47	-56	-66	-81	-94	-112	-131	-145	-163
Waste	185	190	192	200	205	219	227	239	248	248	278	280	269
Total emissions (without lucf)	3322	3163	3070	3112	3059	3113	3204	3388	3406	3579	3352	3212	3181
Total net emissions (with lucf)	3316	3148	3045	3075	3012	3057	3138	3307	3312	3467	3221	3067	3019

* industrial process carbon dioxide emissions fulfilling decision 14/CP.7 are not included in national totals

The distribution of the greenhouse gas emissions over the UNFCCC sectors in 2002 is shown in figure 2.11. Emissions from the energy sector accounts for 61% of the national total emissions and agriculture and industrial processes account for 16 and 15% respectively. The waste sector accounts for 8% and solvent use is not estimated.

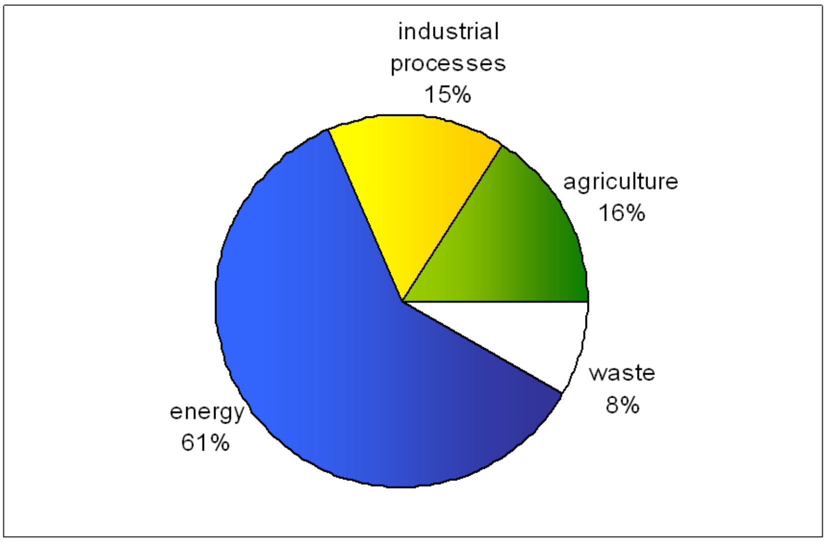


Figure 2.11 Emissions of greenhouse gases by UNFCCC sector in 2002

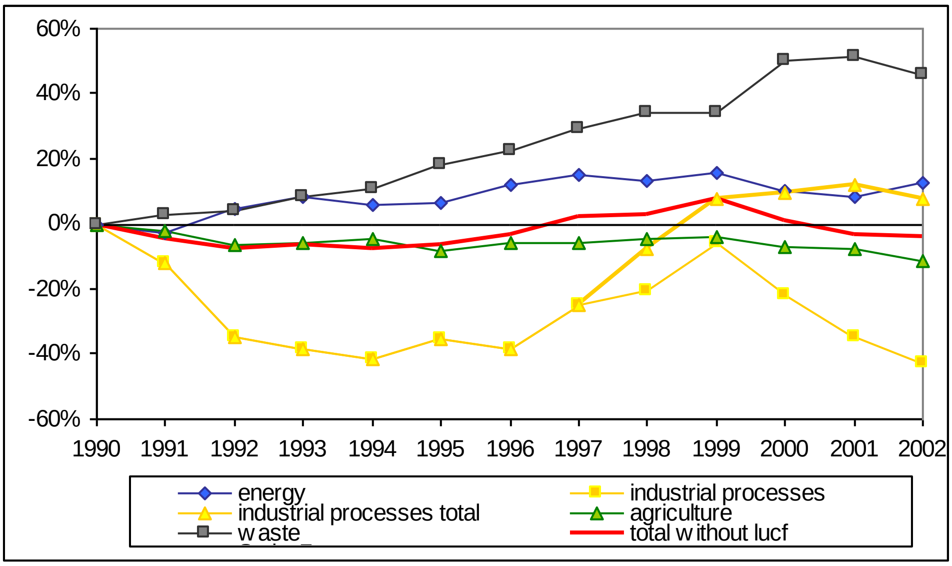


Figure 2.12 Percentage changes in emissions of total greenhouse gas emissions by UNFCCC source categories during the period 1990 – 2002, compared to 1990

2.3.1 Energy

The energy sector in Iceland is unique in many ways. In 2000 the per capita energy use was close to 500 MJ, which is high compared to other industrial countries, but the proportion of domestic renewable energy in the total energy budget is 70%, which is a much higher than in most other countries. The cool climate and sparse population calls for high energy use for spatial heating and transport. Iceland relies heavely on geothermal energy for spatial heating and on hydropower for electricity production.

The total emissions of greenhouse gases from the energy sector over the period of 1990 – 2002 are listed in table 2.8. Figure 2.13 shows the distribution of emissions in 2002 in different source categories. The percentage changes detected in the various source categories in the energy sector between 1990 and 2002, compared to 1990 are illustrated in figure 2.14.

Table 2.8 Total emissions of greenhouse gases from the energy sector in 1990 – 2002, Gg CO_2-eq.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Energy industries	20,7	22,3	21,3	21,2	21,1	22,9	17,5	12,8	36,3	19,2	14,1	14,2	15,3
Manufacturing ind. & construction	376,5	299,5	351,2	379,5	359,8	375,8	418,7	490,2	464,0	491,4	444,7	476,3	476,0
Transport	608,4	619,9	630,2	630,8	633,5	615,0	605,4	623,6	626,8	657,1	659,5	670,4	674,2
Other sectors	697,5	715,0	778,6	810,4	791,5	802,6	867,3	838,3	801,1	800,5	753,2	682,4	749,9
Fugitive emissions	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	1703	1657	1781	1842	1806	1816	1909	1965	1928	1968	1871	1843	1915

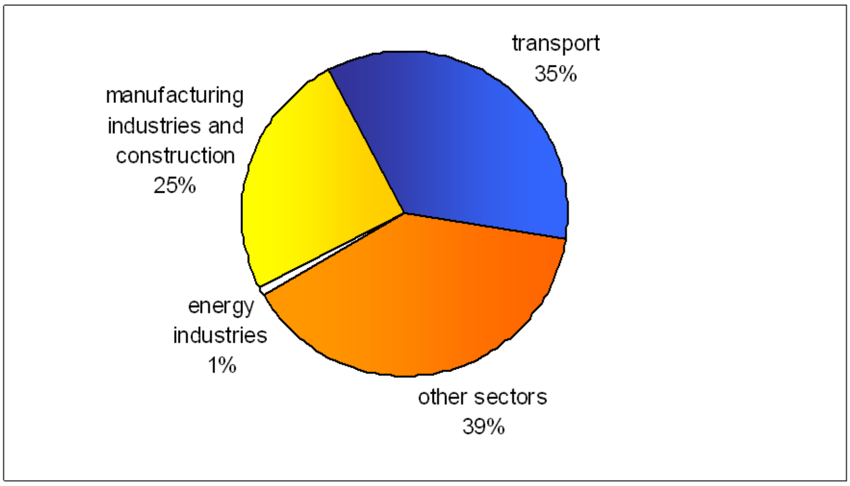


Figure 2.13 Greenhouse gas emissions in the energy sector 2002, distributed by source categories

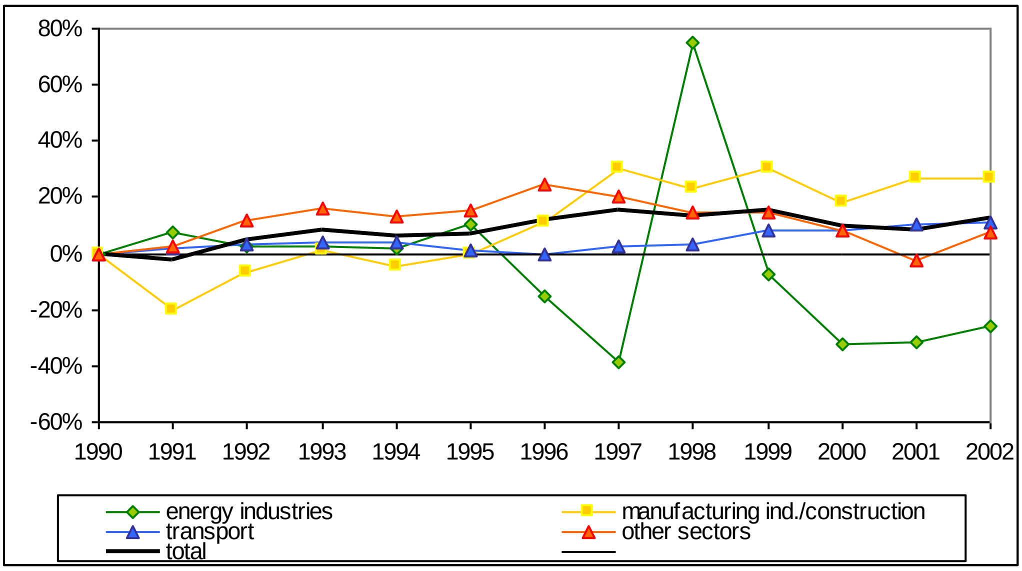


Figure 2.14 Percentage changes in emissions in various source categories in the energy sector during the period 1990 – 2002, compared to 1990

As can been seen from table 2.8 emissions from all source categories except energy industries have been increasing during the period. The peak in the energy industries in 1998 was due to unusual weather condition during the winter of 1997/1998, which lead to a unfavourable water conditions for the hydropower plants reservoirs. This lead to a shortage of electricity which was compensated by using oil for electricity and heat production. The rise of emissions in the manufacturing industries and construction source category is dominated by the increased activity in the construction sector during the period, and to a lesser extend to the rise of emissions from the fishmeal industry. The 'other sector' is dominated by the fisheries. Emissions from fisheries were rising from 1990 to 1996 when a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 emissions decreased again reaching 1990 levels again in 2001 but increased again by 10% between 2001 and 2002. Annual changes are inherent in the nature of fisheries. In the 1990s the vehicle fleet in Iceland almost doubled. This has lead to an increase in the transport sector. A decrease in navigation and aviation has however compensated this effect to some extend.

2.3.2 Industrial processes

Production of raw materials is the main source of process related industrial emissions for both CO_2 and other greenhouse gases such as N_2O (fertilizer production terminated in 2001) and PFCs (aluminium production). The industrial process sector accounts for about 15% of the national greenhouse gas emissions, excluding emissions falling under Decision 14/CP.7 and about 26% of the total national greenhouse gas emissions including emissions falling under Decision 14/CP.7. As can be seen from figure 2.15 and table 2.9 emissions decreased from 1990 to 1996, mainly because of decrease in PFC-emissions. During the late nineties large-scale industry expanded in Iceland. The existing aluminium plant and the ferroallyos industry experienced enlargement in 1997 and 1999, and in 1998 a new aluminium plant was established. This lead again to an increase in industrial process emissions. As mentioned before industrial process carbon dioxide emissions from a single project falling under Decision 14/CP.7 are to be reported separately and are not included in national totals. Since 1999 industrial process emissions, excluding emissions fulfilling decision 14/CP.7, have been decreasing again.

Table 2.9 Total greenhouse gas emissions from the industry sector 1990 – 2002, Gg CO_2-eq.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Mineral Products	51,8	48,2	45,3	39,3	36,8	37,2	41,2	45,8	53,6	60,8	64,8	58,0	39,8
Chemical Industry	48,4	46,8	41,9	44,0	44,3	42,2	49,3	41,1	35,8	36,2	18,6	16,2	0,0
Metal Production	759,6	658,7	471,7	444,8	417,5	447,6	409,1	520,2	530,2	655,3	553,9	431,6	412,5
- Ferroalloys	*203,5*	*171,1*	*182,3*	*230,9*	*224,9*	*238,0*	*227,0*	*248,9*	*192,3*	*249,9*	*203,5*	*203,5*	*203,5*
- Aluminium	*556,1*	*487,6*	*289,5*	*213,8*	*192,5*	*209,6*	*182,1*	*271,3*	*337,9*	*405,4*	*350,4*	*228,1*	*209,0*
- Aluminium CO_2	*136,5*	*139,3*	*134,2*	*139,0*	*148,0*	*150,7*	*156,9*	*188,9*	*157,8*	*232,2*	*223,3*	*136,5*	*136,5*
- Aluminium PFC	*419,6*	*348,3*	*155,3*	*74,9*	*44,6*	*58,8*	*25,1*	*82,4*	*180,1*	*173,2*	*127,2*	*91,7*	*72,5*
Other production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Consumption of HFCs and SF_6	5,4	5,4	5,8	6,9	8,5	30,4	33,9	42,8	69,3	64,8	37,7	59,2	40,5
Total	865,2	759,1	564,7	535,0	507,1	557,3	533,5	650,0	688,9	817,0	675,0	565,0	492,8
Emissions fulfilling 14/CP.7									107,7	115,1	272,8	404,3	441,3
Total with 14/CP.7	865,2	759,1	564,7	535,0	507,1	557,3	533,5	650,0	796,7	932,0	947,8	969,3	934,1

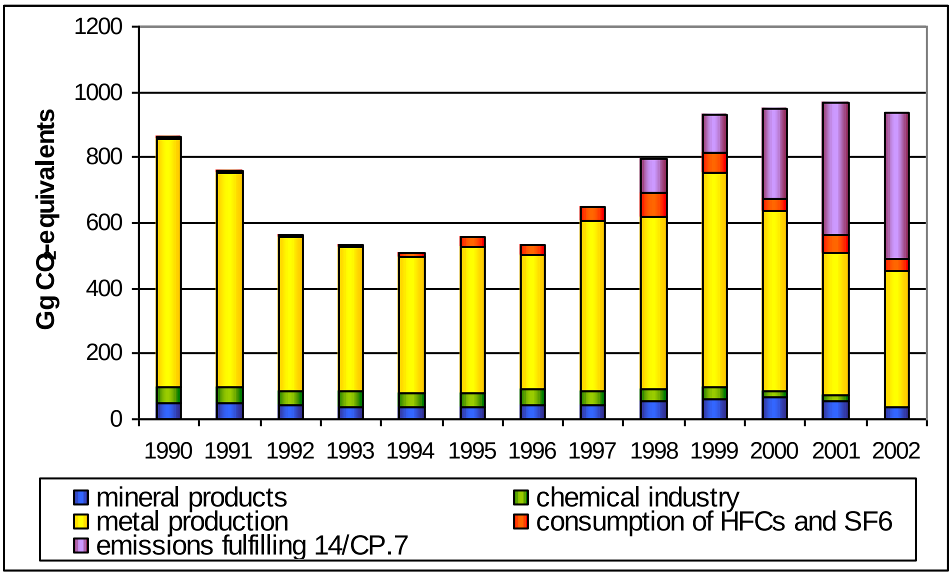


Figure 2.15 Total greenhouse gas emissions in the industrial process sector during the period from 1990 – 2002, Gg CO_2-eq. Emissions fulfilling decision 14/CP.7 are reported separately and not included in national totals.

The main category within the industrial process sector is metal production, which accounted for 88% of the sector's emissions in 1990 and 84% in 2002. Aluminium production is the main source within the metal production category, accounting for 44% of the total industrial process emissions, excluding emissions falling under Decision 14/CP.7, and 50% including all industrial process emissions. The production technology in both existing plants is prebaked anode. The main energy source is electricity, but industrial process CO_2 is emitted from the use of coal electrodes. In addition, the production of aluminium gives rise to emissions of PFCs. From 1990 to 1996 PFC emissions were reduced by 94%. Due to the enlargement of the existing aluminium plant in 1997 and the establishment of new aluminium plant in 1998 emissions increased again from 1997 to 1999, but have decreased since. In 2002 the emissions had decreased by 83% from the 1990 level. The reduction in PFC emissions is caused by improved technology and process control, which has led to reduced PFC emissions per tonne aluminium produced from 4,78 down to 0,27 tonnes CO_2-equivalents in the years 1990 to 2002.

Production of ferroalloys is the other source of emissions from metal production. CO_2 is emitted due to the use of coal and coke as reducing agents, as well as from coal electrodes. In 1998 a power shortage caused a temporary closure of the ferroalloy plant, resulting in uncommonly low emission that year. In 1999 the existing plant was expanded. The emission has therefore increased considerably, but since this emission falls under Decision 14/CP.7 it is reported separately.

Production of minerals is the sector's second most important category accounting for 8% of the emissions in 2002. Cement production is the dominant contributor. Cement is produced in one plant in Iceland, emitting CO_2 from carbon in shell sand used as raw material in the process. Emissions from the cement industry reached a peak in 2000 but have declined since then, partly because of foreign competition on the Icelandic cement market.

The main contributor to the process emissions from the chemical industry has been fertilizer production. The production was terminated in 2001.

Import of HFCs started in 1992 and increased until 1998. Since then annual imports have been between 30 and 60 Gg CO_2-equivalents. Sufficient data are not available to calculate actual emissions. This means that only potential emissions based on imports are estimated. The potential method is likely to overstate emissions, since chemicals used e.g. in refrigerators are emitted over a period of several years. The application category refrigeration contributes by far the largest part of HFCs emissions but foam blowing is also thought to be a minor source.

Sulphur hexafluorid emissions are not estimated but held constant over the whole time series. The largest source of SF_6 emissions is thought to be leakages from electrical equipment.

2.3.3 Solvent and other product use

The use of solvents and products containing solvents leads to emissions of non-methane volatile organic compounds (NMVOC), which is regarded as an indirect greenhouse gas. The NMVOC emissions will over a period of time oxidize to CO_2 in the atmosphere. This conversion has not been estimated so this category has been reported as not estimated (NE).

2.3.4 Agriculture

As can be seen from table 2.10 and figure 2.16 the emissions from agriculture were relatively stable between 1990 and 2002, with emission levels of around 500 Gg CO_2-equivalents per year. During that period emissions decreased by 11%, due to decreasing number of livestock.

Table 2.10 Total greenhouse gas emissions from agriculture in 1990 – 2002, Gg CO_2-eq.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Enteric Fermentation	269,5	263,7	255,6	254,0	255,6	247,2	249,6	252,9	255,9	253,6	242,5	241,8	236,7
Manure Management	55,2	54,0	52,3	52,0	52,1	49,7	50,2	50,5	51,5	50,9	48,2	48,0	47,1
Agricultural Soils	243,7	238,8	223,8	228,5	233,3	224,1	234,6	230,8	233,2	241,4	236,7	234,1	219,6
Total	568,4	556,6	531,7	534,4	541,0	520,9	534,5	534,3	540,5	545,9	527,5	523,9	503,4

Greenhouse gas emissions from agriculture comprise emissions of methane and nitrous oxide. The greenhouse gas emissions from the agricultural sector accounted for 16% of the overall greenhouse gas emissions in 2002. The largest identically large sources for agricultural greenhouse gas emissions are CH_4 from enteric fermentation and N_2O from agricultural soils.

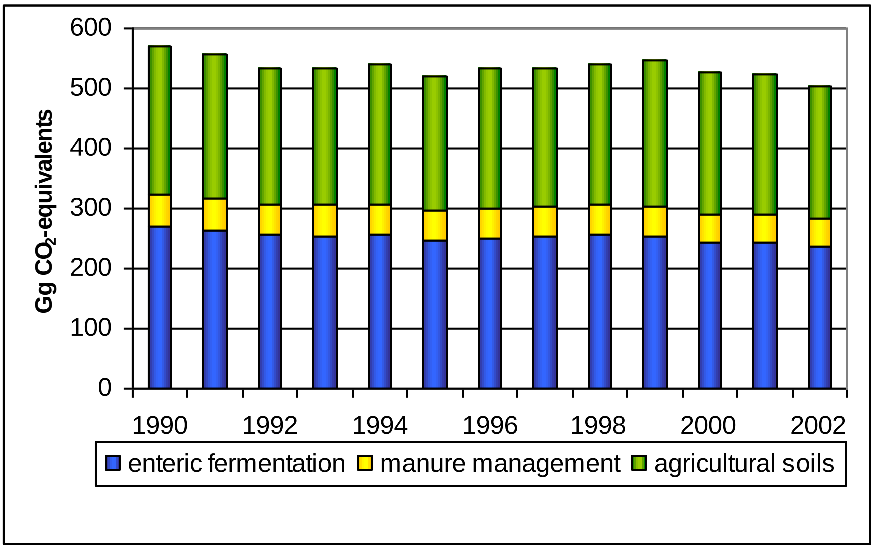


Figure 2.16 Total greenhouse gas emissions from agriculture from 1990 – 2002, Gg CO_2-eq.

2.3.5 Waste

As can be seen from table 2.11 and figure 2.17 the amount of greenhouse gases (CH_4) from landfills have been steadily increasing from 1990 to 2001. From 2001 to 2002 a minor decrease in emissions occured. From 1990 to 2002 the emissions rose by 62%. The reason for the growing emissions is dual. The amount of waste going to landfill sites as well as the percentage going to managed waste disposal sites has been constantly increasing over the period. The amount of waste going to landfill sites increased by 32% over the period. The percentage of waste going to managed waste disposal sites increased from 55% in 1990 to 99% in 2002. Since the methane correction factor is higher for managed waste disposal sites than for unmanaged waste disposal sites, this has lead to increased emissions. The emissions from landfills show a slight decrease from 2001 to 2002, due to increasing amount of methane recovered, but methane recovery started at one landfill site in 1997, and the amount recovered has increased yearly since then.

Emissions from waste incineration have on the other hand decreased constantly since 1990. This is due to the fact that total amount of waste being incinerated in Iceland has decreased and at the same time a higher percentage has been incinerated with energy recovery and is thus reported under 1A1a (public electricity and heat production).

Table 2.11 Emissions from the waste sector from 1990 – 2002, Gg CO_2-eq.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Landfills	163,9	171,7	179,2	187,5	192,7	205,9	216,9	230,1	240,7	241,1	272,3	274,1	265,6
Wastewater Handling	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Waste Incineration	21,2	18,4	12,8	12,8	12,8	12,8	10,0	8,9	7,2	6,7	6,1	6,1	3,9
	185,0	190,1	192,0	200,3	205,5	218,7	226,9	239,1	247,9	247,8	278,4	280,3	269,5

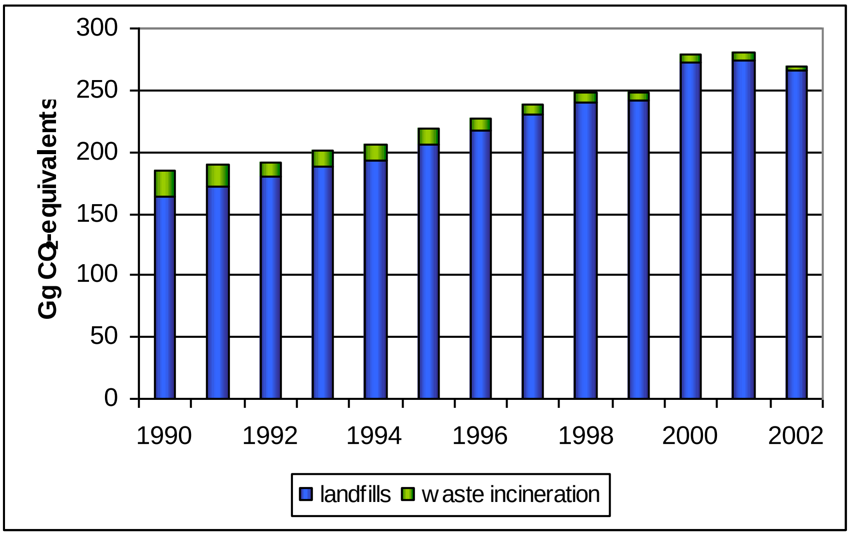


Figure 2.17 Emissions of greenhouse gases in the waste sector 1990 – 2002, Gg CO_2-eq.

2.4 Emission trends for indirect greenhouse gases and SO_2

To be completed for the next submission.

3 ENERGY

3.1 Overview

The energy sector accounts for 61% of the GHG emissions in Iceland. Emissions increased by 12% from 1990 to 2002. From 2001 to 2002 emissions increased by 4%. Fisheries and road traffic are the sector's largest single contributors. Combustion in the manufacturing industries and construction is also an important source.

As indicated in table 1.1, they key source analysis performed for 2002 has revealed that in terms of total level and/or trend uncertainty the key sources in the Energy sector are the following:

- Stationary combustion: oil – CO_2 (1A1, 1A2, 1A4)
- Stationary combustion: coal – CO_2 (1A2f)
- Mobile combustion: construction – CO_2 (1A2f)
- Mobile combustion: road vehicles – CO_2 (1A3b)
- Mobile combustion: road vehicles – N_2O (1A3b)
- Mobile combustion: fisheries – CO_2 (1A4c)

A discussion of the above key sources is presented below, followed by a brief description of cross-cutting issues in this sector.

3.2 Stationary fuel combustion, Oil: CO_2 (1A1, 1A2, 1A4)

3.2.1 Description

This key source refers to CO_2 from combustion of liquid fuels in the energy industries, in the manufacturing industries and construction and in sectors involving commercial/institutional and residential activities. The key source analysis shows that CO_2 emissions from stationary combustion of oil constitute a key source in both level and trend.

Emissions of CO_2 from stationary liquid fuel combustion increased by 16% between 1990 and 2002. In 2002 they constituted about 12% of the total CO_2 emissions in the energy sector and 7% of the total national greenhouse gas emissions.

3.2.2 Methodological issues

Emissions from energy combustion are estimated at the sectoral level. They are calculated by multiplying energy use by source and sector with pollutant specific emission factor. Activity data are provided by the National Energy Authority (NEA), which collects data on fuel sales by sector. Iceland relies heavely on geothermal energy for spatial heating and hydropower for electricity production. Emissions in this key source originate predominantly from the combustions in the manufacturing industries, in particular the fishmeal industry.

Activity data

Total use of different oil products is based on the NEAs annual sales statistics for fossil fuels. The data is considered very reliable since all oil companies selling oil products report those statistics. There is thus a given total, which the usage in the different sectors must sum up to. There is not a clear distinction between the energy industries sector and residential sector in fuel sales statistics. NEA has on request by Environmental and Food Agency (EFA) distinguished the fuel consumption between those two sectors. The EFA collects consumption data from all major industry installations and the consumption of the fishmeal industry is estimated from production statistics.

Emission factors

For liquid fuels the CO_2 emission factors used reflect the average carbon content of the fuels. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in table 3.1.

Table 3.1 Emission factors for CO_2 from the combustion of oil

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]
Kerosene (heating)	44,75	19,60	0,99	3,18
Gas / Diesel Oil	43,33	20,20	0,99	3,18
Residual fuel oil	40,19	21,10	0,99	3,08

3.2.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable and the uncertainty of the emissions factors is likely to be less than 5%.

3.2.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

3.2.5 Recalculations

Fuel consumption was classified differently between the Residential sector and the Energy Industries sector. This did not have an effect on the total amount of emissions.

3.2.6 Planned improvements

There are at present no plans for further improvements in this sector.

3.3 Stationary fuel combustion, coal: CO_2 (1A2f)

3.3.1 Description

This key source refers to CO_2 from combustion of coal in the cement industry. The key source analysis states that this is a key source in trend. Emissions of CO_2 from stationary coal combustion decreased by 30% between 1990 and 2002.

3.3.2 Methodological issues

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

Activity data

EFA collects activity data directly from the single operating cement production plant and the data is thus considered very reliable.

Emission factors

NCV for Coking Coal is taken from NEA and CO_2 emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in table 3.2.

Table 3.2 Emission factors for CO_2 from the combustion of coal

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]
Coking Coal	28,05	25,80	0,98	2,60

3.3.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable and the uncertainty of the emissions factors is likely to be less than 5%.

3.3.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

3.3.5 Recalculations

No recalculations have been performed for this sector.

3.3.6 Planned improvements

There are at present no plans for further improvements in this sector.

3.4 Mobile combustion: construction – CO_2 (1A2f)

3.4.1 Description

This key source refers to CO_2 from mobile combustion in the construction sector. The key source analysis shows that CO_2 emissions from combustion in the construction sector constitute a key source in both level and trend.

Emissions of CO_2 from stationary liquid fuel combustion increased by 49% between 1990 and 2002. In 2002 they constituted about 9% of the total CO_2 emissions in the energy sector.

3.4.2 Methodological issues

Emissions are calculated by multiplying energy use with pollutant specific emission factor. Activity data are provided by the National Energy Authority (NEA), which collects data on fuel sales by sector.

Activity data

Total use of oil products in the construction sector is based on the NEAs annual sales statistics for fossil fuels. The data is considered very reliable since all oil companies selling oil products report those statistics. In some instances oil which is reported to fall under vehicle usage, is actually used for machinery and vice versa. This on the other hand is very minimal and the deviation is believed to level out.

Emission factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in table 3.3.

Table 3.3 Emission factors for CO_2 and N_2O from combustion in the construction sector

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	N_2O EF [t N_2O/kt fuel]
Gas / Diesel Oil	43,33	20,20	0,99	3,18	1,3

3.4.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable and the uncertainty of the emissions factors for CO_2 is likely to be less than 5%. The uncertainty of the emission factor for N_2O is likely to be much higher.

3.4.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

3.4.5 Recalculations

Diesel fuel consumption of machinery was replaced from the Transport sector to the Construction sector. This did not have an effect on the total amount of CO_2 emissions, but raises the emissions of N_2O since the emission factor is about 7,5 times higher than the emission factor used for N_2O from road transport.

3.4.6 Planned improvements

There are at present no plans for further improvements in this sector.

3.5 Mobile combustion: road vehicles – CO_2 and N_2O (1A3b)

3.5.1 Description

CO_2

Emissions of CO_2 from road traffic dominate the total emissions in the transport sector and are an important part of the total national greenhouse gas emissions. In 2002 the emissions contributed 90% of the transport sector and 19% of the total national greenhouse gas emissions. Emissions increased by 19% between 1990 and 2002 due to the increasing number of vehicles and annual mileage driven. This source category is key source in both level and trend.

N_2O

Emissions of N_2O from road traffic accounted for around 9% of the total N_2O emissions in 2002. Since 1990 the emissions have increased by 549%, but the main increase has been after 1995 when catalytic converters became an obligation in all new vehicles. This source category is a key source with respect to trend.

3.5.2 Methodological issues

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 are provided by the National Energy Authority (NEA), which collects data on fuel sales by sector.

Activity data

Total use of diesel oil and gasoline are based on the NEAs annual sales statistics for fossil fuels. The data is considered very reliable since all oil companies selling oil products report those statistics. The EFA estimates how fuel sale is divided between the different types of vehicles, but the method used is considered to be inaccurate.

Emission factors

For CO_2 the standard emission factors based on carbon content of the fuels are used. Emission factors for CH_4 and N_2O depend upon vehicle type and emission control. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in table 3.4.

Table 3.4 Emission factors for greenhouse gases from european vehicles, g/kg fuel

	CH_4	N_2O	CO_2
Passenger car – gasoline, uncontrolled	0,8	0,06	3070
Passenger car – gasoline, non catalyst control	1,1	0,08	3070
Passenger car – gasoline, three way catalyst	0,3	0,8	3070
Light duty vehicle – gasoline	0,8	0,06	3070
Heavy duty vehicle – gasoline	0,7	0,04	3070
Passenger car – diesel	0,08	0,2	3180
Light duty vehicle – diesel	0,06	0,2	3180
Heavy duty vehicle – diesel	0,2	0,1	3180

3.5.3 Uncertainties

The quantitative uncertainty has not been evaluated. For CO_2 emissions from road transport the activity data are considered reliable and the uncertainty of the emissions factors is likely to be less than 5%. For N_2O on the other hand both activity data and emission factors are highly uncertain, depending on factors like driven milage per vehicle type, age of vehicle, maintainance, individual driving manners, cold start emissions, functionality of catalytic converters in cool cimates, etc.

3.5.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

3.5.5 Recalculations

Diesel fuel consumption of machinery was replaced from the Transport sector to the Construction sector. This leads to lower emissions fram road transport than reported earlier, though the total amount of CO_2 emissions from the combined source categories does not change. Combined emissions of N_2O are higher since the emission factor for the construction sector is about 7,5 times higher than the emission factor used for N_2O from road transport.

3.5.6 Planned improvements

Improved estimates on how fuel sale is divided between the different types of vehicles.

3.6 Mobile combustion: fisheries – CO_2 (1A4c)

3.6.1 Description

Emissions of CO_2 from fisheries are a major source in Iceland. In 2002 CO_2 emissions from fisheries contributed 37% of the energy sector and 22% of the total greenhouse gas emissions in Iceland. Emissions of CO_2 from fisheries increased by 8% between 1990 and 2002. The key source analysis shows that CO_2 emissions from fisheries constitute a key source in both level and trend.

3.6.2 Methodological issues

Emissions are calculated by multiplying energy use with pollutant specific emission factor. Activity data are provided by the National Energy Authority (NEA), which collects data on fuel sales by sector.

Activity data

Total use of residual fuel oil and gas/diesel oil for the fisheries is based on the NEAs annual sales statistics for fossil fuels. The data is considered very reliable since all oil companies selling oil products report those statistics.

Emission factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in table 3.5.

Table 3.5 Emission factors for CO_2, CH_4 and N_2O for ocean going ships

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	EF CO_2 [t CO_2/t fuel]	EF N_2O [kg N_2O/TJ fuel]	N_2O EF [kg N_2O/kt fuel]	EF CH_4 [kg CH_4/TJ fuel]	EF CH_4 [kg CH_4/t fuel]
Gas / Diesel Oil	43,33	20,20	0,99	3,18	2	0,86	7	0,30
Residual fuel oil	40,19	22,00	0,99	3,08	2	0,84	7	0,28

3.6.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable and the uncertainty of the emissions factors for CO_2 is likely to be less than 5%. The uncertainty of the emission factor for N_2O and CH_4 is likely to be much higher.

3.6.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

3.6.5 Recalculations

No recalculations have been done in this sector since last submission.

3.6.6 Planned improvements

There are at present no plans for further improvements in this sector.

3.7 Non-key sources

This section will be completed for the next submission.

3.8 International bunker fuels

Emissions from international aviation and marine bunker fuels are excluded from national totals as required according to the IPCC Guidelines. Emissions are presented separately for information and can be seen in table 3.6.

In 2002, greenhouse gas emissions from ships and aircraft in international traffic bunkered in Iceland amounted to a total of 522 Gg CO_2-equivalents, which corresponds to about 16% of the total Icelandic greenhouse gas emissions. Greenhouse gas emissions from marine and aviation bunkers increased by around 60% from 1990 to 2002, and between 2001 and 2002 emissions rose by 4%.

Looking at the two categories, international marine and aviation bunkers separately, it can be seen that greenhouse gas emissions from international marine bunkers increased by 109% from 1990 to 2002, while emissions from aircrafts increased by 41% during the same period. Between 2001 and 2002 emissions from marine bunkers increased by 39%, but at the same time emissions from aviation bunkers decreased by 11%.

Table 3.6 Greenhouse gas emissions from international aviation and marine bunkers, Gg CO_2-eq.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Marine	100,0	38,0	60,6	98,4	94,5	145,5	125,2	150,2	178,4	165,6	220,8	150,6	209,5
Aviation	221,6	224,0	205,4	197,4	215,5	238,3	273,9	294,7	341,1	366,6	411,4	352,2	312,6
Total	321,6	262,0	266,0	295,8	310,0	383,8	399,2	445,0	519,5	532,2	632,2	502,8	522,1

3.8.1 Methodological issues

Emissions are calculated by multiplying energy use with pollutant specific emission factor. Activity data are provided by the National Energy Authority (NEA), which collects data on fuel sales by sector. These data distinguish between national and international usage. The data is considered very reliable since all oil companies selling oil products report those statistics. The emission factors for marine bunkers are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in table 3.5 above. Emission factors for aviation bunkers are also taken from the IPCC Guidelines (Tier 1 method).

3.9 Cross-cutting issues

3.9.1 Sectoral versus reference approach

This section will be completed for the next submission.

3.9.2 Feedstock and non-energy use of fuels

Emissions from the use of feedstocks are according to the Good Practice Guidance accounted for in the industrial processes sector in the Icelandic inventory. This includes all use of petroleum coke, other bituminous coal and coke oven coke.

Iceland uses a carbon storage factor of 1 for bitumen and 0,5 for lubricants for the non-energy use in the Reference Approach, CRF table 1(A)d.

4 INDUSTRIAL PROCESSES

The industrial process sector accounts for 15% of the GHG emissions in Iceland. Emsissions decreased by 43% from 1990 to 2002 when emissions falling under Decision 14/CP.7 are excluded but increased by 8% when they are included. The main category within the intustrial process sector ist metal production, which accounted for 84% of the sectors emissions in 2002.

As indicated in table 1.1, the key source analysis performed for 2002 has revealed that in terms of total level and/or trend uncertainty the key sources in the Industrial Processes sector are the following:

- Emissions from Ferroalloys – CO_2 (2C2)
- Emissions from Aluminium Production – CO_2 (2C3)
- Emissions from Aluminium Production – PFCs (2C3)
- Emissions from Cement Production – CO_2 (2A1)
- Emissions from Substitutes for Ozone Depleting Substances – HFCs (2F)

A discussion of the above key sources is presented below.

4.1 Emissions from Ferroalloys – CO_2 (2C2)

4.1.1 Description

Emissions of CO_2 from the single operating ferroalloy production plant accounted for 6% of the national total greenhouse gas emissions in 1990. In 2002 the share of the total national emissions had was still 6% when emissions fulfilling decision 14/CP.7 are excluded but was 11% when those emissions are included in national totals. This source category is key source in level.

4.1.2 Methodological issues

Emissions of CO_2 originate from the use of coal and coke as reducing agent, as well as from coal electrodes. Emissions are calculated according to Tier 1 method based on the consumption of reducing agents and electrodes and emission factors from the IPCC Guidelines.

Activity data

The consumption of reducing agents and electrodes are collected by EFA directly from the single operating ferroalloys production plant. The data is thus considered very reliable.

Emission factors

For CO_2 the standard emission factors based on carbon content of the reducing agents and electrodes are used. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in table 4.1. Values for NCV are from NEA.

Table 4.1 Emission factors for CO_2 from production of ferroalloys

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t input]
Other Bituminous Coal	28,00	25,80	0,98	2,60
Coke Oven Coke	28,00	29,50	0,98	2,97
Electrodes	28,00	32,14	0,98	3,23

4.1.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable and the uncertainty of the emissions factors is likely to be less than 5%.

4.1.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

4.1.5 Recalculations

No recalculation have been performed for this source.

4.1.6 Planned improvements

There are at present no plans for further improvements in this sector.

4.2 Emissions from Aluminium Production – PFCs, CO_2 (2C3)

4.2.1 Description

Emissions from the aluminium industry accounted for 17% of the national total greenhouse gas emissions in 1990. In 2002 the share of the total national emissions was 7% when emissions falling under Decision 14/CP.7 are excluded but was 13% when those emissions are included in national totals. Total emissions from the aluminium industry, including emissions falling under Decision 14/CP.7, have decreased by 16% from 1990 to 2002. Total CO_2 emissions from the aluminium industry has increased by 188% over the period but PFC emissions have decreased by 83% from the 1990 level. From 1990 to 1996 PFC emissions were reduced by 94%. Due to the enlargement of the existing aluminium plant in 1997 and the establishment of new aluminium plant in 1998 emissions increased again from 1997 to 1999, but have decreased since. The reduction in PFC emissions is caused by improved technology and process control, which has led to reduced PFC emissions per tonne of aluminium produced from 4,78 down to 0,27 tonnes CO_2-equivalents in 1990 to 2002. CO_2 emissions from the aluminium industry is a key source category in level and PFC emissions both in level and trend. The production technology in both existing plants is prebaked anode.

4.2.2 Methodological issues

CO_2

CO_2 emissions originate from the use of coal electrodes. Emissions are calculated according to Tier 1 method based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines.

PFCs

PFCs are produced during anode effects (AE) in the prebake cells, when the voltage of the cells increases from the normal 4 – 5 V to 25 – 40 V. Emissions of PFCs are dependent on the number of anode effects and their intensity and duration. Anode effect characteristics are different from plant to plant. Emission factors are calculated according to the Tier 2 Slope Method. Default coefficients are taken from the IPCC Good Practice Guidance for Centre Worked Prebaked Technology. Emission factors are calculated with the following formula:

$$EF \text{ (kg } CF_4 \text{ of } C_2F_6 \text{ per tonne of Al)} = \text{Slope} \bullet \text{AE min/cell day}$$

Emissions are then calculated by multiplying the emission factors with produced amount of aluminium.

Activity data

EFA collects annual process specific data from the two operating aluminium plants. The data is considered reliable.

Emission factors

For CO_2 the standard emission factors based on carbon content of the electrodes are used. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in table 4.2. The default coefficients for the calculation of PFC emissions are taken from the IPCC Good Practice Guidance for Centre Worked Prebaked Technology (0,14 for CF_4 and 0,018 for C_2F_6). The emissions calculated in this way seem to fit well to the measurements that have been performed at both plants. The measurements took place in 1997 at the old plant and in 2001 at the new one.

Table 4.2 Emission factors CO_2 from aluminium production

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t input]
Electrodes	31,35	31,42	0,98	3,54

4.2.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable and the uncertainty of the emissions factors for CO_2 emissions is likely to be less than 5%. The emission factors for calculating have more uncertainty but still seem to fit well to the measurements that have been performed so far at the aluminium production plants.

4.2.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

4.2.5 Recalculations

The country specific method used before for estimating PFCs from aluminium production did not take into account the duration of the anode effect. The method for estimating PFC emissions from the aluminium industry was thus upgrated from the country specific method to the Tier 2 Slope Method. The old formula used for calculations of emission factor for CF_4 was:

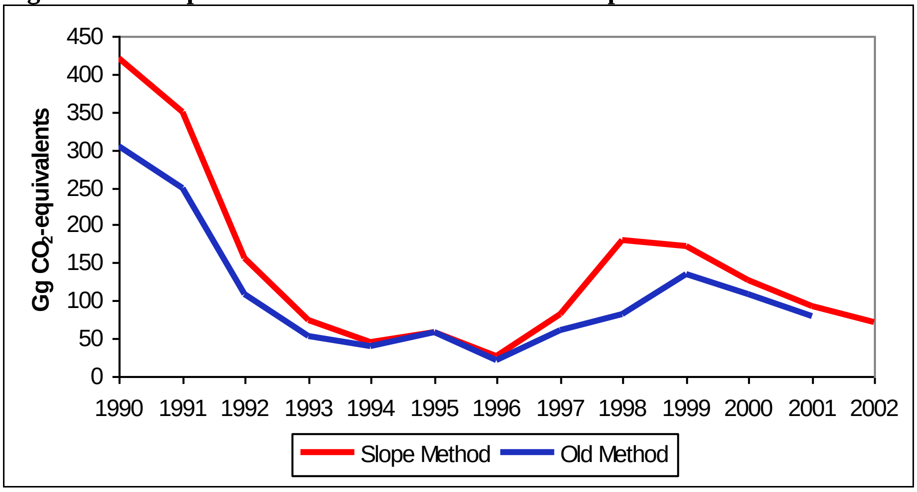
$$EF \text{ (kg } CF_4 \text{ per tonne of Al)} = AEF \bullet 0{,}6 \text{ kg } CF_4\text{/t Al/year}$$

AEF: Number of anode effects per cellday

The assumption behind this formula was that the anode effect duration (AED) time would be 5,5 minutes. When AED departed from the estimated 5,5 minutes the level of estimated emissions proved to be inaccurate. Emissions of C_2F_6 were then set to 10% of the CF_4 emissions.

Figure 4.1 compares calculated emissions from the old method with the new method. It can be seen that the main difference is in the period 1990 – 1992 and then again in 1997 – 1999 which is the time period when the existing aluminium plant experienced an enlargement and a new aluminium plant was established. In those periods the anode effect duration time was high. In other years the methods are comparable.

Figure 4.1 Comparison of the old method and the slope method to calculate PFC emissions



4.2.6 Planned improvements

There are at the present no plans for further improvements in this sector.

4.3 Emissions from Cement Production – CO_2 (2A1)

4.3.1 Description

Emissions of CO_2 from the single operating cement production plant accounted for 8% of the industrial process emissions in 2002 and 1% of the national total greenhouse gas emissions in 2002. Emissions decreased by 23% from 1990 to 2002. This source category is key source in level.

4.3.2 Methodological issues

Emissions of CO_2 originate from the calcination of the raw material calcium carbonate which is taken from shell sand in the production process. The resulting calcium oxide is heated to form clinker and then crushed to form cement. Emissions are calculated according to Tier 2 method based on clinker production data and data on the CaO content of the clinker. Cement Kiln Dust (CKD) is non-calcined dust produced in the kiln. CKD may be partly or completely recycled to the kiln. Any

CKD that is not recycled can be considered lost to the system in terms of CO_2 emissions. Emissions are thus corrected with plant specific cement kiln dust correction factor.

Activity data

Process specific data on clinker production, CaO content of the clinker and non-recycled CKD are collected by EFA directly from the single operating cement production plant. The data is considered reliable.

Emission factors

It has been estimated by the cement production plant that CaO content of the clinker is 63%. The corrected emission factor for CO_2 is thus 0,495. For CKD it is 7,5%.

4.3.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable.

4.3.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

4.3.5 Recalculations

Method for estimating CO_2 emissions from the cement industry was upgrated from Tier 1 method using cement production data and an emission factor of 0,4402 tonnes CO_2 per tonne cement, to the Tier 2 method, with CKD correction. This lead to only minor changes in emissions.

4.3.6 Planned improvements

There are at present no plans for further improvements in this sector.

4.4 Emissions from Substitutes for Ozone Depleting Substances – HFCs (2F)

4.4.1 Description

Import of HFCs started in 1992 and increased until 1998. Since then annual imports have been between 30 and 60 Gg CO_2-equivalents. Sufficient data are not available to calculate actual emissions. This means that only potential emissions are estimated, based on imports. In 2002 the potential emissions of HFCs were around 1% of national total greenhouse gas emissions. This source category is key source in both level and trend.

4.4.2 Methodological issues

Data on imports of HFCs are reported directly to EFA. The data is considered reliable.

4.4.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered reliable. Emissions are likely to be overestimated since only potential emissions are calculated.

4.4.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

4.4.5 Recalculations

No recalculations have been performed for this source.

4.4.6 Planned improvements

Estimating actual HFC emissions.

4.5 Non-key sources

This section will be completed for the next submission.

5 SOLVENT AND OTHER PRODUCT USE

NMVOC emissions will over a period of time oxidize to CO_2 in the atmosphere. This conversion has not been estimated so this category has been reported as not estimated (NE).

6 AGRICULTURE

The agriculture sector accounts for 16% of the GHG emissions in Iceland. Emissions decreased by 11% from 1990 to 2002. The largest identically large sources within the agriculture sector are CH_4 emissions from enteric fermentation (47% of the sector's total) and N_2O emissions from agricultural soils (44% of the sector's total).

As indicated in table 1.1, the key source analysis performed for 2002 has revealed that in terms of total level and/or trend uncertainty the key sources in the agriculture sector are the following:

- Emissions from Enteric Fermentation – CH_4 (4A)
- Direct Emissions from Agricultural Soils – N_2O (4D1)
- Indirect Emissions from Agricultural Soils – N_2O (4D2)

A discussion of the above key sources is presented below.

6.1 Emissions from Enteric Fermentation – CH_4 (4A)

6.1.1 Description

The production of CH_4 by enteric fermentation in animals varies with digestive system and feed intake. Ruminants such as cattle and sheep produce the largest amount of methane. However, enteric fermentation in pseudo-ruminants (e.g. horses) and monogastric animals (e.g. pigs) is also of significance. CH_4 emissions from enteric fermentation amounted to 237 Gg CO_2-equivalents in 2002 and have decreased by 12% since 1990. This source category is key source in level and trend.

6.1.2 Methodological issues

The methodology for calculating methane from enteric fermenation is in accordance with the Tier 1 method. The number of animals of each kind and emission factors for each kind of animals are used to calculate the emissions.

Activity data

Livestock statistics are provided by the Icelandic Association of farmers. The data is considered relatively reliable.

Emission factors

Emission factors are taken from the IPCC Guidelines. They are presented in table 6.1. Those emission factors are likely to be too high, since domestic animals in Iceland are generally smaller (sheep, horses) than in Europe.

Table 6.1 Emission factors for CH_4 from enteric fermentation

	kg CH_4 per head per year
Dairy cattle	100
Non-dairy cattle	48
Sheep	8
Horses	18
Swine	1,5

6.1.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered relatively reliable but the uncertainty of the emissions factors is likely to be high.

6.1.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

6.1.5 Recalculations

Figures for the number of animals have been revised, since previous livestock statistics did not take all young animals into account. This has lead to an increase of about 17%.

6.1.6 Planned improvements

Develop country-specific emission factors.

6.2 Emissions from Agricultural Soils – N_2O (4D)

6.2.1 Description

Three sources of N_2O from agricultural soils are distinguished in the IPCC methodology:

- Direct emissions from agricultural soils (applying for Iceland: use of synthetic fertilisers, applied animal manure, crop residue, cultivation of soils (NE)). This is a key source in both level and trend.
- Direct soil emissions from production of animals
- N_2O emissions indirectly induced by acgricultural activities (N losses by volatilisation, leaching and runoff). This is key source in level.

6.2.2 Methodological issues

The methodology for calculating N_2O from agricultural soil is in accordance with the Tier 1b method.

Use of synthetic fertiliser

The direct emissions of N_2O from the use of synthetic fertilser are calculated from data on annual usage of fertiliser and its nitrogen content, multiplied by the IPCC default emission factor. The emissions are corrected for ammonia that volatilises during application.

Manure applied to soil

It is assumed that all animal excreta that are not deposited during grazing are used as manure. The total amount of nitrogen in manure is estimated from the number of animals and the country-specific nitrogen factors for each kind of animal, presented in table 6.2.

Table 6.2 Nitrogen excretion factors

	kg N per head per year
Dairy cattle	60
Non-dairy cattle	33,6
Sheep	5,76
Horses	28,8
Swine	13,3
Poultry	0,42

Crop residue

This source is negligible.

Cultivation of organic histosols

This source is not estimated.

Direct soil emission from animal production

The fraction of the total amount of animal manure produced, that is deposited on pastures during grazing, is set to be 40 - 45% and differs between years. The Agricultural College at Hvanneyri has estimated the proportion of excreted nitrogen from different types of livestock subject to different types of animal waste management systems. The level of animal manure deposited on pastures has been changing slightly due to changes in farming practices.

N losses by volatilisation

Atmospheric deposition of nitrogen compounds fertilises soils and surface waters, and enhanches biogenic N_2O formation. Climate and the type of fertiliser influence the ammonia volatilisation. The IPCC default values for volatilisation are used (10% for synthetic fertilisers and 20% for animal manure).

N_2O from leaching and runoff

A considerable amount of nitrogen from fertilisers is lost from agricultural soils through leaching and runoff. Fertiliser nitrogen in ground water and surface waters enhances biogenic production of N_2O as the nitrogen undergoes nitrification and denitrification. The IPCC default value of 30% is used.

Emission factors

The IPCC default emission factor of 0,0125 kg N_2O-N/kg N has been used for all sources of direct N_2O emissions from agricultural soils, except the emissions of N_2O

from animal production is calculated using the IPCC default factor of 0,02 kg N_2O-N/kg N.

The IPCC default emission factor of 0,025 kg N_2O-N/kg N is used for leaching and runoff.

6.2.3 Uncertainties

The quantitative uncertainty has not been evaluated. The overall uncertainty of N_2O emissions from agricultural soils are likely to be very high.

6.2.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

6.2.5 Recalculations

During the last year Iceland´s emissions inventory has taken substantial changes. Most of these changes were done in response to a desk review of the greenhouse gas inventory of Iceland submitted in year 2001, and published by the Secretariat on 12. March 2003. The greatest changes were in the agricultural sector and include:

- Methods and emission factors for estimating N_2O were adjusted to the IPCC Guidelines. Calculation of emissions from the use of mineral fertiliser did not account for volatilisation and did not use default emission factors before. Calculations of emissions from application of animal manure had wrong emission factor (by factor 10) and did not follow the IPCC guidelines in every way.
- Figures for number of animals were revised, since former livestock statistics did not take all young animals into account.
- Inclusion of sources that were not estimated before (indirect soil emissions, emissions from grazing animals)

This has lead to an increase of about 83% in the agricultural sector and of about 250% in N_2O emissions from agricultural soils.

6.2.6 Planned improvements

Revise country-specific N excretion factors.

6.3 Non-key sources

This section will be completed for next submission

7 LUCF

7.1 Overview

The Revised IPCC 1996 Guidelines (IPCC 1997) divide the sectoral report for Land-Use Changes and Forestry on greenhouse gasses emission and removal to five categories. Emission and removal from Forest and Grassland Conversion, Abandonment of Managed Lands and CO_2 Emission and Removals from Soil have not been estimated in Iceland due to lack of information. Changes in Forest and Other Woody Biomass Stocks and changes due to Revegetation under the category "Other" are reported. The reporting is limited to activities since 1990 in accordance with the Kyoto protocol.

New methodology for reporting the LULUCF part is presently being elaborated by IPCC. The drafts on Good Practice Guidance already presented include far more extensive accounting of land use and land use changes than hereto practiced in Iceland(IPCC 2003). Iceland does have the technical know-how to meet the requirements of the new methodology regarding land use and land use changes registration. Establishment of a Land use database according to approach 3 in the above named draft methodology for LULUCF should be a realistic goal to achieve in near future. The decision to use GHG removal by afforestation and revegetation leaves no alternatives but that approach for those land-use categories. Conversion of land use information to emission and removal of GHG will require considerable efforts in research and monitoring. Prior to any research input a comprehensive ranking of priorities in parameters to be addressed is necessary. Ongoing research projects do address some of the parameters. Provided funding will be available the reporting to the Convention should be in next future extend to cover all main land use categories with variable tier level according to available information and category importance.

7.2 Changes in forest and woody biomass stock

7.2.1 Overview

The changes in forest and woody biomass stock reported include only afforestation since 1990 meeting the requirements of the Kyoto protocol. The total area of native woodlands in Iceland has been inventoried twice in the 20th century 1972-1975 and 1987-1991 resulting in estimates of 125 and 118 kha respectively. Total woody C-stock was from these data estimated at 1300 ktonn C with average of 11 t C ha^{-1} in 1990. The two inventories are not comparable in methodology and can not be directly compared to show changes in area or woody stock during this period (Sigurðsson and Snorrason 2000).

The C stock of the native birch woodlands is assumed to remain constant, and no changes reported.

Afforestation and reforestation started in Iceland 1899. Before 1970 plantation of forest was mostly done in natural woodlands. The total area of plantations from 1970 to 1989 has been estimated to be 3 kha. The annual changes of the woody biomass of these plantations have not been estimated directly with inventories.

Most of afforestation areas in Iceland are relatively young and clear cutting have not started. The only exceptions of deforestation are when natural woodland and plantations have to give way for road or house building. A preliminary investigation of deforestation have shown that they are very rare and in small scale. Neither the clear cuttings nor the thinning of managed forests is presently systematically recorded.

The whole process of forest inventories and aggregation of forestry data is under total revision and total recalculations will not be conducted until that revision is completed.

7.2.2 Methodological issues

The area of new plantations is estimated from number of seedlings delivered from plant breeding stations. The estimation of afforested area is based on following assumptions. On average planting density was 4000 seedlings ha^{-1}, 25% of afforested area is lost to various reasons (Sigurðsson and Snorrason 2000).

The annual C uptake factor used in report is 1.2 t C ha^{-1} is a precautionary estimate of data from Icelandic Forest Research (Snorrason 2003). The estimated removal of C is based on this factor.

7.2.3 Uncertainties

The use of average annual C removal factor introduces an overestimate of the removal of C by young plantations. The C uptake factor is based on measurements where the biomass of forest plantations of known age was measured. These measurements have resulted in highly variable results ranging from 0.9-3.8 t C ha^{-1} (Jónsson 1996) (Snorrason 2003).

How well the used factor represents the actual plantations is thus a source of error, which acts both on age of plantation and spatial variability. The area estimate is based on indirect data source and no evaluation of its precision has been done.

7.2.4 Source specific QA/QC and verification

No assessment or control of data quality has been undertaken. The ongoing improvement and data base establishment will improve control and verification options.

7.2.5 Recalculations

The area of forest/biomass stock was revised leading to negligible changes.

7.2.6 Planed improvements

A national forest inventory that consists of area based (GIS) database and measurements of carbon stock and carbon stock changes on 3000 systematically spread plots is under construction where all natural woodlands and forest plantations are included. This work started 2 years ago and in this summer the measurement on field plot will start and the country will be covered in a 5 years period. One can therefore expect gradually improved estimate of carbon stock and carbon stock changes in both managed and unmanaged woodlands in Iceland.

7.3 Other - Revegetation

Changes in soil and vegetation carbon stock in land which has been revegetated are reported under the category “Other” in the Land Use Changes and Forestry sector.

7.3.1 Overview

Since settlement of Iceland large areas of the former vegetated areas have been severely eroded and in large areas the entire soil mantel has been swept away. It has recently been estimated that total of 60-250 $*10^3$ kt C has been oxidised and released to the atmosphere in past millennium (Óskarsson, Arnalds et al. 2004).

The current ongoing loss of SOC due to erosion was in the same study estimated 50-100 kt C yr^{-1} (Óskarsson, Arnalds et al. 2004). No attempt is made to include that estimation in the CRF.

By revegetation of deserted areas some of the carbon lost previously is sequestrated back into the soil.

The Icelandic Soil Conservation was established in 1907. Its main obligation has from that time and still is to stop the ongoing erosion and revegetate the lost areas. Until 1970 recording of soil conservation and revegetation activities was very limited only occasional maps and reports. From 1970 to 1990 most of the activities included spreading of seeds and/or fertilizers by aeroplanes. These activities are to large extent recorded. From 1990 the importance of the flight has decreased as other methods have taken over and cooperation with farmers and other parties of interest has increased. At the same time recording of activities has developed.

The reported removal of CO_2 is what is estimated to have been removed in areas established since 1990 and is accountable with respect to the Kyoto protocol. Older revegetations are not included.

No effort has been taken to estimate separately the emission or removal of other GHG. The emission of N_2O due to use of N-fertilizers on revegetation sites is included in the national total release due to fertilizers usage.

7.3.2 Methodological issues

The Icelandic Soil Conservation records the revegitation efforts conducted. In 1998-2000 a special governmental effort to sequester carbon with revegetation and afforestation was carried out. Along with that effort a research effort to document carbon sequestration and estimate its rate was carried out (Arnalds, Guðbergsson et al. 2000).

An effort in GIS mapping of the revegetation areas and improvements of the precession of size estimate of the areas has been ongoing since 1998. Both the rate estimate and area recording aim at establishing a transparent, verifiable inventory for revegetation efforts accountable according to the Kyoto protocol.

7.3.3 Uncertainties

There are two main sources of error regarding carbon sequestration by revegetation. First is variability in sequestration rate and the second is estimate of area size.
The areas where revegetation is carried out are very variable regarding soil, and climate condition and method used. Success of revegetation efforts is also very variable. Consequently to this variability the rate of sequestration is highly variable. Although some of the sources of this variability have been identified, it is far from being totally explained (Arnalds, Aradóttir et al. 1999; Arnalds, Guðbergsson et al. 2000; Arnalds 2002).

The mapping method and registration of the revegetation on the first year of recording 1998 was based on recording the site name and estimate of hectares where activity were taking place. The estimated number of hectares is partly based on amount of seeds and fertilizers used. This method possible introduced relative large error into the area estimates and also there is a risk of double counting or not counting some areas.

Generally it is a necessary part of the revegetation effort to protect the area from grazing by establishing permanent fences. In some cases the whole area inside such fences are possible reported as revegetated although only a part of it has been directly the field of activities such as fertilization or seed spreading. It is important to bear in mind that the registration was designed to serve other purposes than the needs of greenhouse gas inventories.

7.3.4 Source specific QA/QC and verification

The Icelandic Soil Conservation is working on improvements of recording the revegetion activities. In the first phase the improvements are on the activities conducted since 1990. The estimation of sequestration rate was carried out along with the special governmental sequestration effort described above. Since then no verification of real sequestration has been carried out.

7.3.5 Recalculations

No recalculations are carried out in this report, but re-estimations are needed as soon as the mapping of the revegetation areas is completed.

7.3.6 Planed improvements

Two main improvements are planed and partly already being carried out. First there is improvement in recording of activities both, in location and description of activities and management. Second improvement planed is pre activity sampling to establish a baseline fore comparison of SOC to later time.

7.4 Planed improvements regarding LULUCF reporting

IPCC is preparing detailed Good Practice Guidance for LULUCF part of the reporting to the Convention (IPCC 2003). The drafts already sent to the parties do attempt to cover comprehensively all land-use and possible changes in land-use. To meet the requirements of this new Good Practice Guidance for LULUCF Iceland needs to:

1. Establish a land-use database relevant to GHG inventory.
2. Provide funding for research and monitoring of most relevant parameters for converting land-use and land-use changes to emission and removal of GHG.

The preparation of this work has started with the goal that and improvements in reporting can be rationalised in 2005 reporting to the Convention for the year 2003.

8 WASTE

8.1 Overview

The waste sector accounts for 8% of the GHG emissions in Iceland. Emissions increased by 46% from 1990 to 2002. CH_4 emissions from solid waste disposal sites is by far the largest source within the waste sector (99% of the sector's total). Emissions from Wastewater Handling are not estimated but are thought to be minor.

As indicated in table 1.1, the key source analysis performed for 2002 has revealed that in terms of total level and/or trend uncertainty the key sources in the agriculture sector are the following:

- Emissions from Solid Waste Disposal Sites – CH_4 (6A)
- Emissions from Waste Incineration – CO_2 (6C)

A discussion of the above key sources is presented below.

8.2 Emissions from Solid Waste Disposal Sites – CH_4 (6A)

8.2.1 Description

Methane emissions from solid waste disposal on land account for around 8% of national total greenhouse gas emissions. This source category is key source in level and trend.

8.2.2 Methodological issues

The methodology for calculating methane from solid waste disposal on land is in accordance with the Tier 1 method. The amount of waste going to managed waste disposal sites on the one hand and unmanaged waste disposal sites (shallow, less than 5 meters of waste) on the other hand, and the methane generation potential of each kind of disposal site are used to calculate the emissions. The following equation is used:

$$CH_4 \text{ emissions (Gg/yr)} = [(MSW_L \bullet L_0) - R] \bullet (1 - OX)$$

MSW_L: MSW disposed at SWDS
L_0: Methane generation potential
R: Recovered methane (Gg/yr)
OX: Oxidation factor (fraction)

The oxidation factor for managed waste disposal sites is set at 0,1[1] and for unmanaged waste disposal sites at 0. The methane generation potential is calculated from the composition of landfilled waste, with the following equation:

$$L_0 \text{ (Gg } CH_4\text{/Gg waste)} = MCF \bullet DOC \bullet DOC_F \bullet F \bullet 16/12$$

MCF: Methane correction factor (fraction)
DOC: Degradable organic carbon (fraction [Gg C/ Gg MSW])
DOC_F: Fraction DOC dissimilated
F: Fraction by volume of CH_4 in landfill gas

[1] According to IPCC Good Practice Guidance, most industrialised countries with well-managed SWDS use 0,1 for OX

The methane correction factor accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS.

Activity data

Activity data on waste in Iceland are very incomplete in every respect. There is little information on the actual amount of generated waste as well as on its composition and characteristics. The largest operating disposal site has though since 1990 weighted all incoming wastes and done some surveys on its composition. This information has been used by EFA to make estimations on waste amount and composition for the whole country. Statistics for 2002 have been used to estimate historical data, assuming the generated waste to have increased by 1,5% per capita per year. The composition of the landfilled waste is held constant over the time series. Landfilled waste is divided between managed waste disposal sites and unmanaged shallow (less than 5 meters of waste) waste disposal sites. Estimates on how waste is divided between the different types of waste disposal sites depend on whether the waste disposal sites are operated with or without permission from EFA. Waste going to landfill sites without permissions is classified as waste going to unmanaged shallow (less than 5 meters of wastes) waste disposal sites. The data is considered to be very unreliable. Data on methane recovery are collected by EFA directly from the single landfill site with methane recovery. Those data are considered to be reliable.

Data and values used to calculate the methane generation potential

Data and values to calculate the methane generation potential are mainly taken from the IPCC Guidelines. The methane correction factor for managed waste disposal sites is 1 and for unmanaged – shallow it is 0,4. The fraction by volume of CH_4 in landfill gas is set at 0,5. DOC is estimated using default carbon content values and the fraction of each waste stream by weight, based on estimations from EFA (EFA 2004):

$$DOC = (0{,}4 \bullet A) + (0{,}17 \bullet B) + (0{,}15 \bullet C) + (0{,}3 \bullet D)$$

Values for calculating DOC are presented in table 8.1.

Table 8.1 Values for calculating the DOC in solid waste disposed on land

Waste Stream	DOC (% by weight)	Fraction of MSW (% by weight)
A. Paper and textiles	40	20
B. Garden and park wastes	17	4
C. Food waste	15	33
D. Wood and straw waste	30	0,2

The fraction of degradable organic carbon dissimilated is set at 0,55 in accordance with the IPCC Good Practice Guidance.

8.2.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered very unreliable and the uncertainty of the emissions factors is likely to be high. Although all waste that is landfilled with permission from EFA is considered as waste going to managed solid waste disposal sites it is quite unlikely that the amount of generated methane is as high as is assumed by the Tier 1 method for managed waste disposal sites. This is due to the fact that many of these landfill sites are shallow and the weather condition are unfavourable for methane generation. Still, until some better data is available it has been decided to perform the calculations in this way. This may lead to some overestimation of methane emissions from landfilled wastes. This source category presumably represents the greatest uncertainty of the inventory.

8.2.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

8.2.5 Recalculations

Since last submissions figures for landfilled wastes have been revised. Also methods and emission factors for estimating methane from solid waste disposal on land were adjusted to the IPCC Guidelines. This has lead to an increase from about 47 Gg CO_2-eq in 2001 in last submission to 174 Gg in 2001 in this submission.

8.2.6 Planned improvements

Since waste statistics in Iceland are very poor and the uncertainty in methane emission from landfilled waste is very high it is a matter of priority to carry out surveys to obtain better data on the waste sector in Iceland. A survey like this needs to be carried out as soon as possible since it is forseen that the amount of carbon deposited at SWDS will go down in the future. Enough data to use the First Order Decay method needs to be compiled.

8.3 Emissions from Waste Incineration – CO_2 (6C)

8.3.1 Description

Emissions from waste incineration in district heating plants are reported in sector 1A1a (public electricity and heat production). Emissions from waste incineration have decreased by 82% from 1990 to 2002. This is due to the fact that the total amount of waste being incinerated in Iceland has decreased and at the same time a higher percentage has been incinerated with energy recovery and is thus reported under 1A1a. This source category is key source in trend.

8.3.2 Methodological issues

The methodology for calculating emissions from waste incineration is in accordance with the IPCC Guidelines. The activity data are the waste inputs into the incinerator, and the emission factor is based on the carbon content of the waste that is of fossil origin only. The burn out efficiency of the combustion is also included in the calculation. Although the most accurate way to estimate CO_2 emissions is by disaggregating the activity data into different waste types (e.g. municipal solid waste, clinical waste, hazardous waste) this could not be done for this submission. The following equation is used for calculating CO_2 emissions from waste incineration:

$$CO_2 \text{ emissions (Gg/yr)} = IMSW \bullet CCW \bullet FCF \bullet BEF \bullet 44/12$$

IMSW: Amount of incinerated waste (Gg/yr)
CCW: Fraction of carbon content in waste
FCF: Fraction of fossil carbon in waste
BEF: Burn out efficiency of incinerator

44/12: Conversion from C to CO_2

Activity data

Activity data on incinerated wastes are collected by EFA. The data are considered rather reliable.

Emission factors

Data for estimation of CO_2 from waste incineration are default values for municipal solid waste (MSW) taken from the IPCC Good Practice Guidance. They are presented in table 8.2.

Table 8.2 Emission factors for CH_4 from solid waste disposal on land

Waste Stream	MSW
C content of waste	40%
Fossil Carbon as % of Total Carbon	40%
Efficiency of Combustion	95%

8.3.3 Uncertainties

The quantitative uncertainty has not been evaluated. The activity data are considered rather reliable.

8.3.4 QA/QC and verification

No formal QA/QC has been performed. Calculations and units have been checked by EFA as well as data consistency between years.

8.3.5 Recalculations

Since last submissions methods and emission factors for estimating CO_2 emissions from waste incineration were adjusted to the IPCC Guidelines. Also emissions from waste incineration with energy recovery are now reported under 1A1a instead of under the waste sector.

8.3.6 Planned improvements

Disaggregating the activity data into different waste types (e.g. municipal solid waste, clinical waste, hazardous waste).

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ANNEX 1: KEY SOURCES

According to the IPCC definition, key sources are those that add up to 90% of the total uncertainty in level and/or in trend. In the Icelandic Emission Inventory key source categories are identified by means of Tier 1 method.

A key source analysis was prepared for this round of reporting. Table 1.1 in Chapter 1 lists identified key sources. Table A1 shows the level assessment of the key source analysis and table A2 the trend assessment of the key source analysis.

Table A1. Key source analysis – level assessment

		1990	2002	Level assessment	Cumulative total
Mobile Combustion: Fishing	CO_2	655,5	705,2	0,23	0,23
Mobile combustion: Road vehicles	CO_2	509,0	603,8	0,19	0,42
CO2 emissions from stationary combustion, oil	CO_2	237,0	274,7	0,09	0,51
CH4 emissions from solid waste disposal sites	CH_4	163,9	265,6	0,08	0,59
CH4 emissions from enteric fermentation in domestic livestock	CH_4	269,5	236,7	0,08	0,67
CO2 emissions from Ferroalloys	CO_2	203,5	203,5	0,07	0,73
Mobile combustion: Construction industry	CO_2	120,7	180,1	0,06	0,79
CO2 emissions from aluminium production	CO_2	136,5	136,5	0,04	0,83
Direct N2O emissions from agricultural soils	N_2O	143,3	129,1	0,04	0,87
Indirect N2O emissions from Nitrogen used in agriculture	N_2O	100,5	90,5	0,03	0,90
PFC emissions from aluminium production	PFC	419,6	72,5	0,02	0,93
CO2 emissions from Cement Production	CO_2	51,6	39,4	0,01	0,94
Emissions from Substitutes for Ozone Depleting Substances	HFC	0,0	35,2	0,01	0,95

Table A1. Key source analysis – trend assessment

			1990	2002	Level assessment	Trend assessment	Contribution to trend	Cumulative total
Industrial processes	**PFC emissions from aluminium production**	**PFC**	**419,6**	**72,5**	**0,02**	**0,110**	**0,380**	**0,38**
Waste	**CH4 emissions from solid waste disposal sites**	**CH4**	**163,9**	**265,6**	**0,08**	**0,034**	**0,118**	**0,50**
Energy	**Mobile combustion: Road vehicles**	**CO2**	**509,0**	**603,8**	**0,19**	**0,034**	**0,117**	**0,62**
Energy	**Mobile Combustion: Fishing**	**CO2**	**655,5**	**705,2**	**0,23**	**0,020**	**0,070**	**0,68**
Energy	**Mobile combustion: Construction industry**	**CO2**	**120,7**	**180,1**	**0,06**	**0,020**	**0,069**	**0,75**
Energy	**CO2 emissions from stationary combustion, oil**	**CO_2**	**237,0**	**274,7**	**0,09**	**0,014**	**0,047**	**0,80**
Industrial processes	**Emissions from Substitutes for Ozone Depleting Substances**	**HFC**	**0,0**	**35,2**	**0,01**	**0,011**	**0,039**	**0,84**
Agriculture	**CH4 emissions from enteric fermentation in domestic livestock**	**CH4**	**269,5**	**236,7**	**0,08**	**0,009**	**0,031**	**0,87**
Energy	**Mobile combustion: Road vehicles**	**N2O**	**4,4**	**28,5**	**0,01**	**0,008**	**0,027**	**0,90**
Waste	**Emissions from waste incineration**	**CO2**	**21,2**	**3,9**	**0,00**	**0,005**	**0,019**	**0,92**
Energy	**CO2 emissions from stationary combustion, coal**	**CO2**	**48,3**	**33,9**	**0,01**	**0,004**	**0,015**	**0,93**
Agriculture	**Direct N2O emissions from agricultural soils**	**N2O**	**143,3**	**129,1**	**0,04**	**0,004**	**0,013**	**0,95**