Emissions of greenhouse gases in Iceland from 1990 to 2008

National Inventory Report 2010

Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

ENVIRONMENT AGENCY OF ICELAND

Authors:
Birna Sigrún Hallsdóttir, Environment Agency of Iceland
Kristín Harðardóttir, Environment Agency of Iceland
Jón Guðmundsson, Agricultural University of Iceland
Arnór Snorrason, Icelandic Forest Research
Jóhann Þórsson, Soil Conservation Service of Iceland

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Preface

The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to the Convention requires the parties 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 2010. The NIR together with the associated Common Reporting Format tables (CRF) is Iceland's contribution to this round of reporting under the Convention and the Kyoto Protocol, and covers emissions and removals in the period 1990 – 2008. The Standard Electronic Format (SEF) is not reported as Iceland has not transferred or acquired any Kyoto Protocol Units.

The NIR is written by the Environment Agency of Iceland (EA), with a major contribution by the Agricultural University of Iceland (AUI).

Environment Agency, Reykjavík, May 2010

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Definition of prefixes and symbols used in the Inventory

Prefix	Symbol	Power of 10
kilo-	k	10^3
mega-	M	10^6
giga-	G	10^9

Gigagrams (Gg) are repeatedly used in the inventory and are equal to 10^9 grams or in a more common language 1000 tonnes.

ABBREVIATIONS

NIR	National Inventory Report
UNFCCC	United Nations Framework Convention on Climate Changes
COP	Conference of the Parties
GHG	Greenhouse gases
AAU	Assigned Amount Units
LULUCF	Land Use, Land-Use Change and Forestry
PFC	Perfluorinated compounds
CRF	Common Reporting Format
IPCC	Intergovernmental Panel on Climate Change
EA	The Environment Agency of Iceland
FAI	Farmers Association of Iceland
GDP	Gross Domestic Product
QA/QC	Quality Assurance/Quality Control
CO_2-eq	Carbon dioxide equivalent
HFC	Hydrofluorocarbon
OECD	Organisation for Economic Co-operation and Development
NMVOC	non-methane volatile organic compounds
EF	Emission factor
AUI	Agricultural University of Iceland
NEA	National Energy Authority
ERT	Expert review team
t/t	Tonne per tonne
IEF	Implied emission factor
KP	Kyoto Protocol
MAC	Mobile Air Conditioning
NOx	Nitrogen oxides
IFS	Iceland Forest Service
SCSI	Soil Conservation Service of Iceland
MSW	Municipal Solid Waste
IW	Industrial Waste
DOC	Degradable Organic Carbon
MCF	Methane Correction Factor
RMU	Removal Unit
SEF	Standard Electronic Format

ITL	International Transaction Log
NNFI	New National Forest Inventory
NIRA	The National Inventory on Revegetation Area
GPS	Global Positioning System
GIS	Geographic Information System
NFI	National Forest Inventory
EU ETS	European Union Greenhouse Gas Emission Trading System
CITL	Community Independent Transaction Log
ERU	Emission Reduction Unit
CER	Certified Emission Unit
GRETA	Greenhouse gases Registry for Emissions Trading Arrangements

EXECUTIVE SUMMARY

Kyoto accounting:

Iceland's AAUs for the first commitment period amount to 18,523,847 tonnes of CO_2 equivalents for the period, or 3,704,769 tonnes per year on average. For 2008, Iceland's total Annex A greenhouse gas emissions were estimated at 4,880 Gg CO_2-equivalents. Iceland's total emissions in 2008 were 43% above 1990 levels. Activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol amounted to 371 Gg CO_2-equivalents in 2008. Those removals could thus raise Iceland's average AAUs to 4,075 Gg per year. Emissions that fall under Decision 14/CP.7 amounted to 1163 Gg CO_2 in 2008. Emissions falling under Decision 14/CP.7 are to be reported separately and shall not be included in national totals; to the extent they would cause Iceland to exceed its assigned amount. In this submission all emissions are reported, as Iceland will undertake the accounting with respect to Decision 14/CP.7 at the end of the commitment period.

Background

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol 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).

The IPCC Good Practice Guidance, the Revised 1996 Guidelines, the 2006 Guidelines and national estimation methods are used in producing the greenhouse gas emissions inventory. The responsibility of producing the emissions data lies with the Environment Agency, which compiles and maintains the greenhouse gas inventory. Emissions and removals from the LULUCF sector are compiled by the Agricultural University of Iceland. The national inventory and reporting system is continually being developed and improved.

Iceland is a party to the UNFCCC and acceded to the Kyoto Protocol on May 23rd, 2002. Earlier that year the government adopted a 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 they do 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 afforestation and revegetation programs. In February 2007 a new climate change strategy was adopted by the Icelandic government. The strategy sets forth a long-term vision for the reduction of net emissions of greenhouse gases by 50-75% by the year 2050, using 1990 emissions figures as a baseline.

The Kyoto Protocol commits Annex I Parties to individual, legally binding targets for their greenhouse gas emissions during 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. Iceland AAU's for the first commitment period amount to 18,523,847 tonnes of CO_2 equivalents.
- Decision14/CP.7 on the "Impact of single projects on emissions in the commitment period" allows Iceland to report certain industrial process' carbon dioxide emissions separately and not include them in national totals; to the extent they would cause Iceland to exceed its assigned amount. For the first commitment period, from 2008 to 2012, the carbon dioxide emissions falling under decision 14/CP.7 shall not exceed 8,000,000 tonnes.

Trends in emissions and removals

In 1990, the total emissions of greenhouse gases in Iceland were 3,415 Gg of CO_2-equivalents. In 2008, total emissions were 4,880 Gg CO_2-equivalents. This is an increase of 43% over the time period.

A summary of the Icelandic national emissions for 1990, 2007 and 2008 is presented in Table ES 1 (without LULUCF). Empty cells indicate emissions not occurring.

Table ES 1. Emissions of greenhouse gases during 1990, 2007 and 2008 in Gg CO_2-eq.

	1990	2007	2008	90-08	07-08
CO_2	2172	3301	3595	52%	8%
CH_4	445	470	467	5%	-1%
N_2O	377	388	396	5%	2%
HFC 32		0.1	0.1	-	9%
HFC 125		20	23	-	13%
HFC 134a		14	15	-	11%
HFC 143a		23	28	-	21%
HFC 152a		0.1	0.1	-	-15%
CF_4	355	238	295	-17%	24%
C_2F_6	65	43	54	-17%	24%
SF_6	1	10	6	468%	-40%
Total	3415	4508	4880	43%	8%
CO_2 emissions fulfilling 14/CP.7			1163	-	-
Total emissions excluding CO_2 emissions fulfilling 14/CP.7			**3717**	**9%**	**-**

The largest contributor of greenhouse gas emissions in Iceland is the energy sector, followed by industrial processes, then agriculture, waste and solvent and other product use. From 1990 to 2008, the contribution of the energy sector to the total emissions decreased from 52% to 43%. The contribution of industrial processes decreased from 25% in 1990 to around 17 - 19% in the period 1992 to 1997. The contribution of industrial processes increased again after 1997 and was 41% in 2008.

Table ES 2. Total emissions of greenhouse gases by source 1990, 2007 and 2008, Gg CO_2-eq.

	1990	2007	2008
Energy	1783	2234	2092
Industrial processes	863	1484	1992
Emission fulfilling 14/CP.7			1163
Solvent Use	14	12	9
Agriculture	575	551	566
Waste	180	226	221
Total	3415	4507	4880
Total excluding emissions falling under 14/CP.7			3717
Removals from KP 3.3 and 3.4			**371**

The distribution of the total greenhouse gas emissions over the UNFCCC sectors (including geothermal energy and excluding LULUCF) in 2008 is shown in Figure ES 1. Emissions from the energy sector account for 43% (fuel combustion 39% and geothermal energy 4%) of the national total emissions, industrial processes account for 41% and agriculture for 12%. The waste sector accounts for 4% and solvent and other product use for 0.3%.

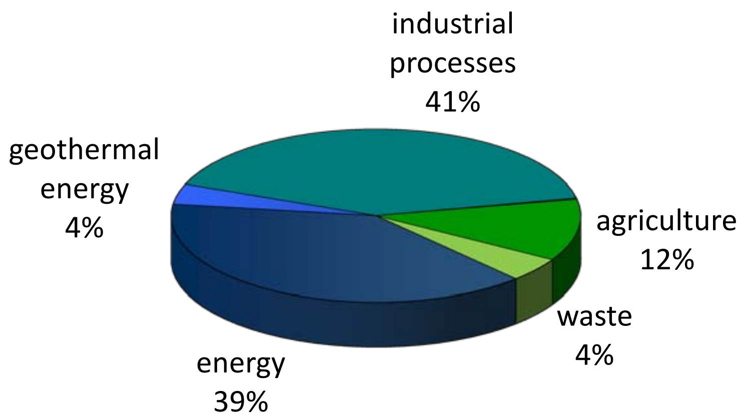

Figure ES 1. Emissions of greenhouse gases by UNFCCC sector in 2008

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 (GHG) 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 of the Framework Convention. The domestic implementation strategy was revised in 2002, based on the commitments of the Kyoto Protocol and the provisions in 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. Iceland AAUs for the first commitment period were decided in Iceland's Initial Report under the Kyoto Protocol and amount to 18,523,847 tonnes of CO_2 equivalents.
- Decision 14/CP.7 on the "Impact of single project on emissions in the commitment period" allows Iceland to report certain industrial process' carbon dioxide emissions separately and not include them in national totals; to the extent they would cause Iceland to exceed its assigned amount. For the first commitment period, from 2008 to 2012, the carbon dioxide emissions falling under decision 14/CP.7 shall not exceed 8,000,000 tonnes.

A new climate change strategy was adopted by the Icelandic government in February 2007[1]. The Ministry for the Environment formulated the strategy 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 long-term strategy is to reduce net greenhouse gas emissions in Iceland by 50 – 75% by 2050, compared to 1990 levels. In the shorter term, Iceland aims to ensure that emissions of greenhouse gases will not exceed Iceland's obligations under the Kyoto Protocol in the first commitment period. The strategy contains provisions for measures to curb and reduce GHG emissions in six sectors, as well as provisions to increase carbon sequestration resulting from afforestation and revegetation programs.

The greenhouse gas emissions profile for Iceland is unusual in many respects. First, emissions from generation of electricity and from space heating are very low owing

[1] http://eng.umhverfisraduneyti.is/media/PDF_skrar/Stefnumorkun_i_loftslagsmalum_en.pdf

to the use of renewable energy sources (geothermal and hydropower). Second, more than 80% of emissions from the energy sector stem from mobile sources (transport, mobile machinery and fishing vessels). Third, emissions from the LULUCF sector are relatively high. Recent research has indicated that there are significant emissions of carbon dioxide from drained wetlands. These emissions can be attributed to drainage of wetlands in the latter half of the 20th Century, which had largely ceased by 1990. These emissions of CO_2 continue for a long time after drainage. The fourth distinctive feature is that individual sources of industrial process emissions have a significant proportional impact on emissions at the national level. Most noticeable are increased 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 fundamental issue associated with the significant proportional impact of single projects on emissions is one of scale. In small economies such as Iceland, a single project 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 aluminium 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 shall not be included in national totals to the extent that they would cause the party to exceed its assigned amount. The total amount that can be reported separately under this decision is set at 1.6 million tonnes 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.

The industrial process carbon dioxide emissions falling under Decision 14/CP.7 cannot be transferred by Iceland or acquired by another Party under Articles 6 and 17 of the Kyoto Protocol. If carbon dioxide emissions are reported separately according to the Decision, that will imply that Iceland can not transfer assigned amount units to other Parties through international emissions trading.

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. Emissions that fall under Decision 14/CP.7 are not excluded from national totals in this report, as Iceland will undertake the accounting with respect to the Decision at the end of the commitment period. The project, from which emissions fulfill the provisions of Decision 14/CP.7 are described in Chapter 4 and Fact sheets for the project can be found in Annex III.

The present report 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 – 2008. The methodology used in calculating the emissions is according to the revised 1996 and 2006 IPCC Guidelines for National Greenhouse Gas Inventories as set out by the IPCC Good Practice Guidance and Good Practice Guidance for Land Use, Land-Use Change and Forestry. The Standard Electronic Format (SEF) is not reported as Iceland has not transferred or acquired any Kyoto Protocol Units.

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

1.2 National system for estimation of greenhouse gases

1.2.1 Institutional arrangement

The Environment Agency of Iceland (EA), an agency under the Ministry for the Environment, carries the overall responsibility for the national inventory. EA compiles and maintains the greenhouse gas emission inventory, except for LULUCF which is compiled by the Agricultural University of Iceland (AUI). EA reports to the Convention. Figure 1.1 illustrates the flow of information and allocation of responsibilities.

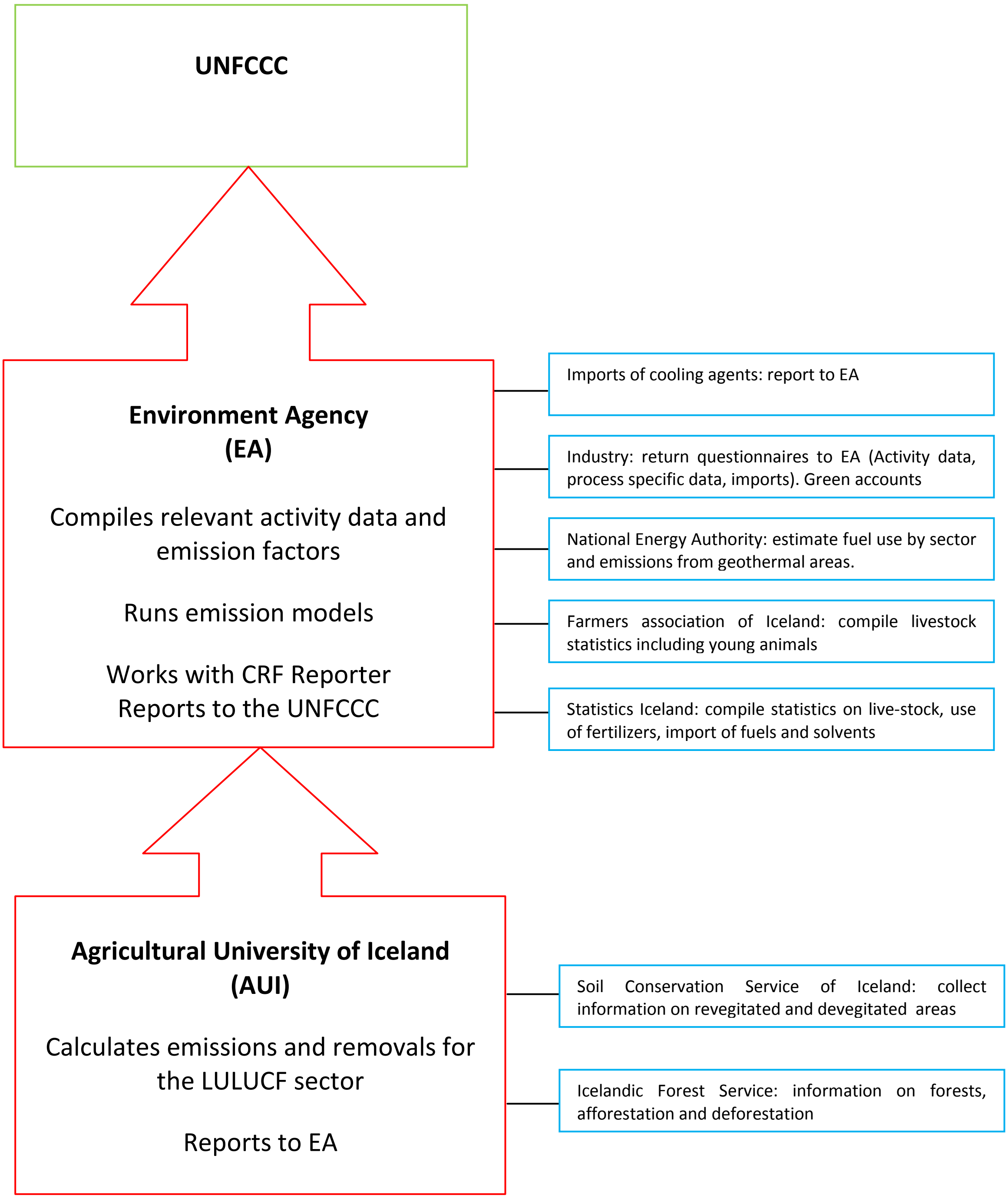

Figure 1.1. Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC

A Coordinating Team was established in 2008 as a part of the national system. The team has representatives from the Ministry for the Environment, the EA and the AUI not directly involved in preparing the inventory. Its official roles are to review the emissions inventory before submission to UNFCCC, plan the inventory cycle and formulate proposals on further development and improvement of the national inventory system. During this inventory cycle the Coordinating Team held 3 meetings. The work of the team has already led to improvement in cooperation between the different institutions involved with the inventory compilation, especially with regards to the LULUCF and agriculture sectors. Some improvements proposed by the team were incorporated into this and last inventory submission.

1.2.2 Act No. 65 from 2007

A new act on the emission of greenhouse gases was passed by the Icelandic legislature, Althing, in March 2007. The stated purpose of the act is to create conditions for Icelandic authorities to comply with international obligations in limiting emissions of greenhouse gases. The act establishes the national system for the estimation of greenhouse gas emissions by sources and removals by sinks, a national registry, emission permits and the duty of companies to report relevant information to the authorities.

The act specifies that the EA is the responsible authority for the national accounting as well as the inventory of emissions and removals of greenhouse gases according to Iceland's international obligations. The EA shall, in accordance with the legislation, produce instructions on the preparation of data and other information for the national inventory. Formal agreements have been made between the EA and the necessary collaborating agencies involved in the preparation of the inventory to cover responsibilities such as data collection and methodologies, data delivery timelines and uncertainty estimates. These involve the National Energy Authority and the Agricultural University of Iceland. The Agricultural University has also made formal agreements with its major data providers, the Soil Conservation Service of Iceland and the Iceland Forest Service. Regulation 244/2009 further elaborates on the reporting of information from the industrial plants falling under the act.

According to the act a three-member Emissions Allowance Allocation Committee, appointed by the Minister for the Environment with representatives of the Ministry of Industry, Ministry for the Environment and the Ministry of Finance, allocates emissions allowance for operators falling within the scope of the Act during the period 1 January 2008 to 31 December 2012.

1.3 Process of inventory preparation

The EA collects the bulk of data necessary to run the general emission model, i.e. activity data and emission factors. Activity data is collected from various institutions and companies, as well as by EA directly. The National Energy Authority (NEA) collects annual information on fuel sales from the oil companies. This information was until 2008 provided on an informal basis. New legislation, Act No. 48/2007, enable the NEA to obtain sales statistics from the oil companies. Farmers Association of Iceland (FAI), on the behalf of the Ministry of Agriculture, is responsible for assessing the size of the animal population each year. On request from the EA, the FAI also accounts for young animals that are mostly excluded from national statistics on animal population. Statistics Iceland provides information on population, GDP, production of asphalt, imports of solvents and other products, the import of fertilizers and on the import and export of fuels. The EA collects various additional data directly. Annually an electronic questionnaire on imports, use of feedstock, and production and process specific information is sent out to industrial producers, in accordance with regulation 244/2009. Green Accounts from the industry are also used. Importers of HFCs submit reports on their annual imports by type of HFCs to the EA. EA also estimates activity data with regard to waste. Emission factors are taken mainly from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC Good Practice Guidance and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, since limited information is available from measurements of emissions in Iceland.

AUI receives information on revegetated areas from the Soil Conservation Service of Iceland and information on forests and afforestation from the Icelandic Forest Service. The AUI assesses other land use categories on the basis of its own geographical database and other available supplementary land use information. AUI then calculates emissions and removals for the LULUCF sector and reports to the EA.

The annual inventory cycle (Figure 1.2) describes individual activities performed each year in preparation for next submission of the emission estimates.

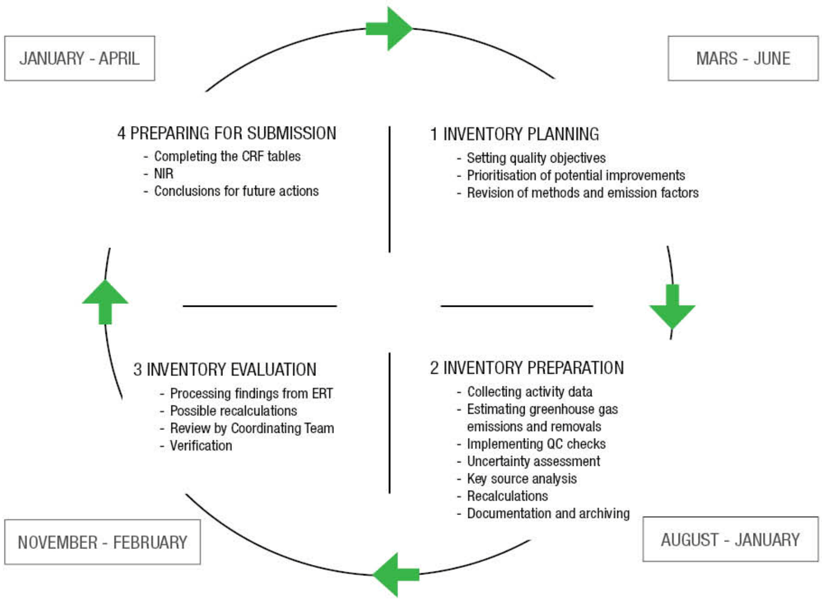

Figure 1.2 The annual inventory cycle

A new annual cycle begins with an initial planning of activities for the inventory cycle by the Coordinating Team, taking into account the recommendations from the UNFCCC review. The initial planning is followed by a period assigned for compilation of the national inventory and improvement of the National System.

After compilation of activity data, emission estimates and uncertainties are calculated and quality checks performed to validate results. Emission data is received from the sectoral expert for LULUCF. All emission estimates are imported into the CRF Reporter software.

A series of internal review activities are carried out annually to detect and rectify any anomalies in the estimates, e.g. time series variations, with priority given to emissions from industrial plants falling under Decision 14/CP.7, other key source categories and for those categories where data and methodological changes have recently occurred.

After final review of the greenhouse gas inventory by the Coordinating Team, the inventory is submitted to the UNFCCC by EA.

1.4 Methodologies and data sources

The estimation methods of all greenhouse gases are harmonized with the IPCC Guidelines for National Greenhouse Gas Inventories and are in accordance with IPCC's Good Practice Guidance.

The general emission model is based on the equation:

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

The model includes the greenhouse gases and in addition the precursors and indirect greenhouse gases NOx, SO_2, NMVOC and CO, as well as some other pollutants (POPs).

Methodologies and data sources for LULUCF are described in Chapter 7.

1.5 Key source categories

According to the IPCC definition, a key source category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both. In the Icelandic Emission Inventory key source categories are identified by means of the Tier 1 method.

A key source analysis was prepared for this round of reporting. Table 1.1 lists the identified key sources. Tables showing key source analysis (trend and level assessment) can be found in Annex I. The key source analysis includes LULUCF sources.

Table 1.1 Key sources

IPCC SOURCE CATEGORIES	Direct GHG	Key source		
		Level '90	Level '08	Trend
ENERGY SECTOR				
1.A.2: Manufacturing Industry And Construction	CO_2	ν	ν	ν
1.A.3b: Road Transport	CO_2	ν	ν	ν
1.A.3 (A,D): Non-Road Transport	CO_2	ν	ν	
1.A.4(A,B): Residential, Commercial, Institutional	CO_2	ν*		ν
1.A.4c: Fishing	CO_2	ν	ν	ν
1.B.2d Geothermal Energy Utilisation	CO_2	ν	ν	ν
INDUSTRIAL PROCESSES				
2.A: Mineral Industry	CO_2	ν	ν*	
2.C.2: Ferroalloys Production	CO_2	ν	ν	ν
2.C.3: Aluminium Production	CO_2	ν	ν	ν
2.C.3: Aluminium Production	PFC	ν	ν	ν
2.F Emissions From Substitutes For Ozone Depleting Substances	HFC		ν	ν
AGRICULTURE				
4.A.1 Enteric Fermentation, Cattle	CH_4	ν	ν	ν
4.A.3 Enteric Fermentation, Sheep	CH_4	ν	ν	ν
4.B Manure Management	N_2O			ν
4.D.1 Direct N_2O Emissions From Agricultural Soils	N_2O	ν	ν	
4.D.2 Indirect N_2O Emissions From Nitrogen Used In Agriculture	N_2O	ν	ν	ν
LULUCF				
5.A Forest Land	CO_2		ν	ν
5.B.2 Cropland	CO_2	ν	ν	ν
5.C.2.3 Wetlands Converted To Grassland	CO_2	ν	ν	ν
5.C.2.5 Other Land Converted To Grassland	CO_2	ν	ν	ν
WASTE				
6.A Solid Waste Disposal Sites	CH_4	ν	ν	ν

*key source excluding LULUCF

1.6 Quality assurance and quality control (QA/QC)

The objective of QA/QC activities in national greenhouse gas inventories is to improve transparency, consistency, comparability, completeness, accuracy, confidence and timeliness. A QA/QC plan for the annual greenhouse gas inventory of Iceland has been prepared. The document describes the quality assurance and quality control programme. It includes the quality objectives and an inventory quality assurance and quality control plan. It also describes the responsibilities and the time schedule for the performance of QA/QC procedures. The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Source category specific QC measures have been developed for several key source categories. A quality manual was prepared for this submission. It can be found on http://www.ust.is/media/fraedsluefni/pdf-skjol//Iceland_QAQC_manual.pdf. To further facilitate the QA/QC procedures all calculation sheets have been revised.

They now include a brief description of the method used. They are also provided with colour codes for major activity data entries and emissions results to allow immediate visible recognition of outliers.

1.7 Uncertainty evaluation

Uncertainty evaluation of the inventory was prepared for this round of reporting. The uncertainty estimate revealed that the total uncertainty of the Icelandic inventory (excluding LULUCF) is 7.4%. The results of the uncertainty estimate can be found in Annex II.

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 emissions 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 2008.

With regard to sectoral coverage few sources are not estimated.

The main sources not estimated are:

- Emissions of CO_2 and CH_4 from distribution of oil products (1B2a v)
- The emissions/removals of some LULUCF components are not estimated (see Chapter 7). Most important is probably the emissions/removals of mineral soils under various land use including cropland and degraded grassland and emissions due to biomass burning.

The reason for not including the above activities/gases in the present submission is a lack of data, and/or that additional work was impossible due to time constraints in the preparation of the emission inventory.

1.9 Planned and implemented improvements

Several improvements have been made since last submissions. The main changes include:

- Change of emission factor for estimation of CO_2 emissions from road transport.
- Shift to Tier 2 for estimation of enteric fermentation from cattle and sheep. In relation to the project animal population statistics were also revised.
- Revision of country specific Nex factors for cattle and swine.
- Cultivation of histosols (organic soils) is now reported under the Agriculture sector.

- The area of drained wetlands is now disaggregated and reported under Wetland converted to Grassland and Wetland converted to Cropland. The drained areas are now geographically identifiable in the Icelandic geographical land use database.
- Changes in carbon stock of mineral soil of forest are now estimated.

In the near future the following improvements are planned:

- Preparation of a national energy balance. The NEA should prepare a national energy balance annually and submit to the EA, in accordance with the formal agreement between EA and NEA.
- The division of land use into subcategories and improved time and spatial resolution of the land use information is an ongoing task of the AUI.
- Ongoing new national forest inventory (NNFI) will further improve both estimates of Forest land area and Carbon stock changes.
- Similar effort as the NNFI regarding Revegetation began in 2007. The revegetation inventory is expected to provide improved data on carbon stock changes and area of revegetated land in the next two years.

The following improvements are under consideration:

- Improvement of methodologies to estimate emissions from road transportation.
- Improvement of QA/QC for LULUCF.
- Improvement of the time series for different land use categories and the estimate on past and present land use changes.
- Revision of LULUCF emission/removal factors, in order to emphasize key sources and aim toward higher tier levels.
- Evaluation of LULUCF factors, not estimated in present submission and disaggregation of components presently reported as aggregated emission.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Emission trends for aggregated greenhouse gas emissions

Total amounts of greenhouse gases emitted in Iceland during the period 1990 – 2008 are presented in the following tables, expressed in terms of contribution by gas and source.

Table 2.1 presents emission figures for greenhouse gases by sector in 1990, 2007 and 2008 expressed in CO_2-equivalents along with the percentage change indicated for both time periods 1990 – 2008 and 2007 – 2008. Table 2.2 presents emission figures for all greenhouse gases by gas in 1990, 2007 and 2008, expressed in CO_2-equivalents along with the percentage change indicated for both time periods 1990 – 2008 and 2007 – 2008. Empty cells indicate emissions not occurring.

Table 2.1 Emissions of greenhouse gases by sector in Iceland during the period 1990 – 2008 (without LULUCF). Units: Gg CO_2-eq.

	1990	2007	2008	Changes 90-08	Changes 07-08
Energy	1783	2234	2092	17%	-6%
Industrial processes	863	1484	1992	131%	34%
Solvent and other product use	14	12	9	-36%	-27%
Agriculture	575	551	566	-2%	3%
Waste	180	226	221	23%	-2%
Total without LULUCF	**3415**	**4508**	**4880**	**43%**	**8%**
CO_2 emissions fulfilling 14/CP.7*			1163		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*			**3716**		

*Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals

Table 2.2 Emissions of greenhouse gases by gas in Iceland during the period 1990 – 2008 (without LULUCF). Units: Gg CO_2-eq.

	1990	2007	2008	Changes 90-08	Changes 07-08
CO_2	2172	3301	3595	65%	9%
CH_4	445	470	467	5%	-1%
N_2O	377	388	396	5%	2%
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SF_6	1	10	6	468%	-40%
Total	**3415**	**4508**	**4880**	**43%**	**8%**
CO_2 emissions fulfilling 14/CP.7*			1163		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*			**3716**		

*Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals

As mentioned in Chapter 1.1 industrial process CO_2 emissions that fulfill Decision 14/CP.7 shall be reported separately and not included in national totals, to the extent they would cause Iceland to exceed its assigned amount.

In 1990, the total emissions of greenhouse gases (excluding LULUCF) in Iceland were 3,415 Gg of CO_2-equivalents. In 2008 total emissions were 4,880 Gg CO_2-equivalents. This implies an increase of 43% over the time period. Total emissions show a decrease between 1990 and 1994, with an exception in 1993, and an increase thereafter. A sudden increase of 15% was seen between 2005 and 2006 followed by an increase of 6% in 2007 and 8% in 2008.

By the middle of the 1990s economic growth started to gain momentum in Iceland. Iceland experienced until 2007 one of the highest growth rates of GDP among OECD countries. Late year 2008, Iceland was severely hit by an economic crisis when it's three largest banks collapsed. The blow was particularly hard owing to the large size of the banking sector in relation to the overall economy as it had grown to be ten times the annual GDP. The crisis has resulted in serious contraction of the economy followed by increase in unemployment, a depreciation of the Icelandic króna (ISK) by over 40% in 2009 compared with the 1st quarter of 2008 and a drastic increase in external debt. Private consumption has contracted by a quarter since 2007.

The main driver behind increased emissions since 1990 has been the expansion of the metal production sector. In 1990, 88,000 tonnes of aluminium were produced in one aluminium plant in Iceland. In 2008, 781,151 tonnes of aluminium were produced in three aluminium plants. Parallel investments in increased power capacity were needed to accommodate for an almost nine fold increase in aluminium production. The size of these investments is large relative to the Icelandic economy. Emissions of greenhouse gases decreased from most sectors between 2007 and 2008. A rise in total emissions between 2007 and 2008 can be attributed to increased emissions from the aluminium industry linked to the start-up of new production capacity.

The increase in GDP since 1990 explains further the general growth in emissions. This has resulted in higher emissions from most sources, but in particular from transport and the construction sector. Since 1990 emission from the transport sector have risen considerably, owing to the fact that a larger share of the population uses private cars for their daily travel. In 2008 fuel prices rose significantly leading to lower emissions from the sector compared to the year before. The knock-off effect of the increased levels of economic growth was an increase in construction, esp. house building in the capital area. The construction of a large hydropower plant (Kárahnjúkar, building time from 2002 to 2007) led to further increase in emissions from the sector. The construction sector collapsed in autumn 2008. Emissions from fuel combustion in the transport and construction sector decreased in 2008 by 5% compared to the year before, because of the economic crises.

The overall increasing trend of greenhouse gas emissions was until 2005 to some extent counteracted by decreased emissions of PFCs, caused by improved technology and process control in the aluminium industry. Increased emissions from the aluminium industry, since 2006, has led to a trend of overall increase in greenhouse gas emissions.

2.2 Emission trends by gas

As shown in Figure 2.1, the largest contributor by far to the total GHG emissions is CO_2 (74%), followed by CH_4 (9%), fluorinated gases PFCs, HFCs and SF_6 (9%) and N_2O (8%). The share of CO_2 has increased by 10% since 1990 and the relative contribution has decreased; CH_4 by 4%, N_2O by 3% and fluorinated gases by 3%.

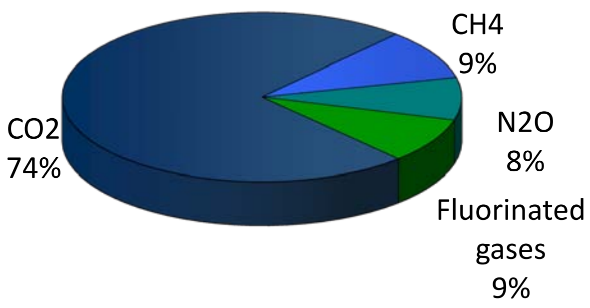

Figure 2.1 Distribution of emissions of greenhouse gases by gas in 2008

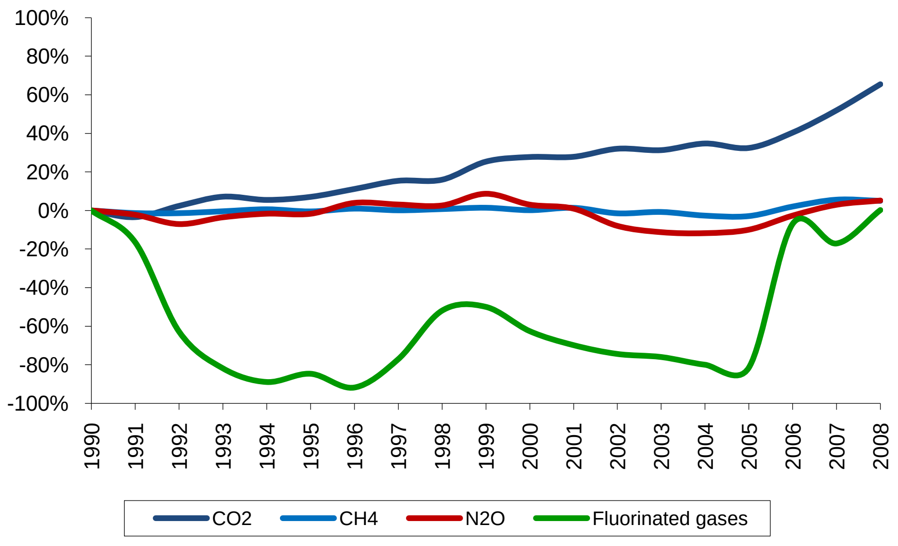

Figure 2.2 Percentage changes in emissions of GHG by gas 1990 – 2008, compared with 1990

Table 2.3 Emissions of greenhouse gases in Iceland during the period 1990 – 2008 (without LULUCF). Units: Gg CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
CO_2	2172	2326	2775	2877	3050	3301	3595
CH_4	445	443	446	432	454	470	467
N_2O	377	370	388	339	367	388	396
HFC		4	27	49	52	57	67
PFC	420	59	127	26	333	281	349
SF_6	1	1	3	3	7	10	6
Total	**3415**	**3204**	**3766**	**3727**	**4263**	**4508**	**4880**
CO_2 emissions fulfilling 14/CP.7*							1163
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*							**3717**

*Decision 14/CP.7 allows Iceland to exclude certain industrial process carbon dioxide emissions from national totals

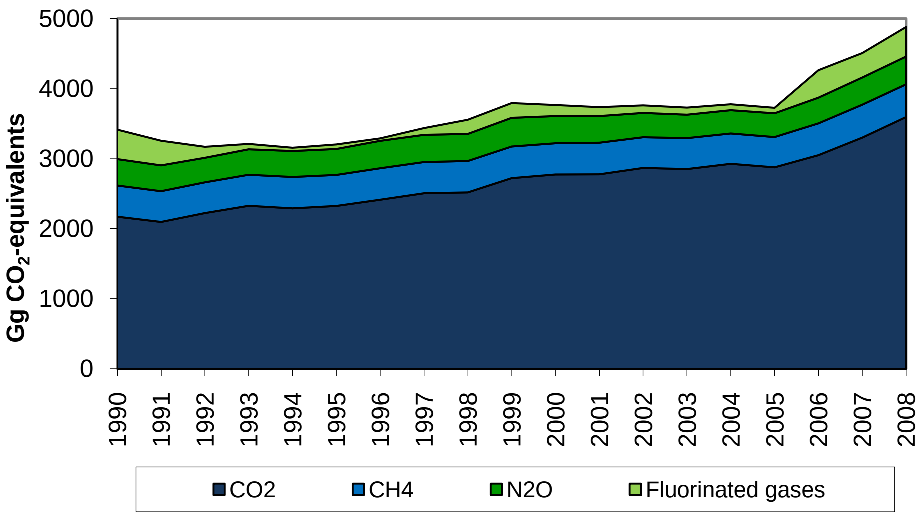

Figure 2.3 Emissions of greenhouse gases by gas, 1990 – 2008

2.2.1 Carbon dioxide (CO_2)

Industrial processes, road transport and fisheries are the three main sources of CO_2 emissions in Iceland. Since emissions from the electricity generation and space heating are low, as they are generated from renewable energy sources, emissions from stationary combustion are dominated by industrial sources. Thereof, the fishmeal industry is by far the largest user of fossil fuels. Emissions from mobile sources in the construction sector are also significant. Emissions from geothermal energy exploitation are moderate. Other sources consist mainly of emissions from coal combustion in the cement industry, and emissions from non-road transport. Table 2.4 lists CO_2 emissions from each source category for the period 1990 – 2008. Figure 2.4 illustrates the distribution of CO_2 emissions by main source categories, and Figure 2.5 shows the percentage change in emissions of CO_2 by source from 1990 to 2008 compared with 1990.

Table 2.4 Emissions of CO_2 by sector 1990 – 2008, Gg CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Fishing	655	772	720	626	549	565	517
Road vehicles	521	547	602	761	872	904	851
Stationary combustion, liquid fuels	246	232	220	210	194	170	118
Industrial processes	393	428	769	838	941	1134	1570
Construction	121	148	197	215	195	196	188
Geothermal	67	82	163	123	156	152	185
Other	169	117	104	104	142	180	166
Total	**2172**	**2326**	**2775**	**2877**	**3050**	**3301**	**3595**

In 2008 the total CO_2 emissions in Iceland were 3,595 Gg. This implies an increase of about 9% from the preceding year. Emissions from industrial processes increased by 38% from 2007 to 2008 and emissions from geothermal energy increased by 22% Emissions from road vehicles declined by 6% due to significantly higher fuel prices, owing to the depreciation of the Icelandic krona during the year. Emissions from stationary combustion of liquid fuels decreased by 31% from 2007 to 2008. Emissions from construction decreased by 4% and emissions from other sources decreased by 8%.

The increase in CO_2 emissions between 1990 and 2008 can be explained by the increased emissions from industrial processes (299%), road transport (63%), geothermal energy utilisation (178%), and the construction sector (55%). Emissions from fishing declined by 21% during the same period.

The main driver behind increased emissions since 1990 has been the expansion of the metal production sector, the aluminium sector in particular. In 1990, 88,000 tonnes of aluminium were produced in one aluminium plant in Iceland which had increased to 781,151 tonnes produced in three aluminium plants in 2008.

CO_2 emissions from road transport have increased by 63% since 1990, owing to an increase in the number of cars per capita, more mileage driven and an increase in larger vehicles. Since 1990 the vehicle fleet in Iceland has increased nearly by 81%. Emissions from both domestic flights and navigation have declined since 1990.

Emissions from geothermal energy exploitation have increased by 178%. Electricity production using geothermal energy has increased from 283 GWh in 1990 to 4038 in 2008, or 14-fold.

Emissions from fishing rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 the emissions decreased again reaching 1990 levels in 2001. Emissions increased again by 10% between 2001 and 2002, but in 2003 they dropped to 1990 levels. In 2008, the emissions were 21% below the 1990 levels. Annual changes in emissions reflect the inherent nature of the fishing industry.

Emissions from other sources decreased from 1990 to 2003, but rose again between 2004 and 2007 when they were 18% above the 1990 level. This is mainly due to changes in the cement industry where production had been slowly decreasing since 1990. The construction of the Kárahnjúkar hydropower plant increased demand for cement, and the production increased again between 2004 and 2007, although most of the cement used in this project was imported. In 2008, emissions from cement production were 4% lower than in 2007.

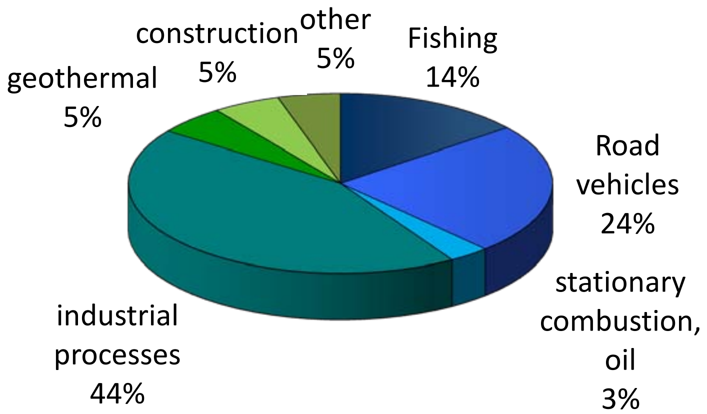

Figure 2.4 Distribution of CO_2 emissions by source in 2008

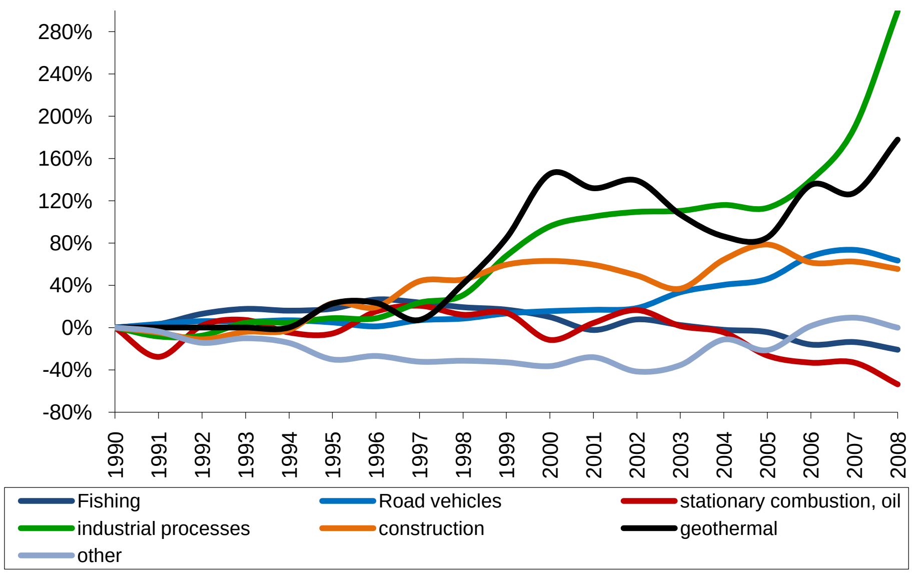

Figure 2.5 Percentage changes in emissions of CO_2 by major sources 1990 – 2008, compared to 1990

2.2.2 **Methane (CH_4)**

As can be seen from Table 2.5 and Figure 2.6, about 45% and 54% of the emissions of methane in 2008 originated from waste treatment and agriculture respectively. The emissions from agriculture decreased by 12% between 1990 and 2008, whereas emissions from waste increased by 39%. Emissions from waste treatment increased from 1990 to 2001 due to a greater amount of waste generated and a higher ratio of landfilled waste in managed waste disposal sites. The emissions from landfills decreased slightly from 2001 to 2005, due to increased methane recovery. The emissions rose by 14% from 2005 to 2008. This increase is mainly due to failures in the methane capture system at the single landfill site where methane is collected, and also due to increased amount of landfilled waste disposed at managed waste disposal sites.

Table 2.5 Emissions of CH_4 by sector 1990 – 2008, CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Agriculture	287	265	256	243	246	249	252
Waste	153	173	185	185	204	217	212
Other	5.3	5.2	4.4	4.2	4.3	4.4	4.0
Total	**445**	**443**	**446**	**432**	**454**	**470**	**467**

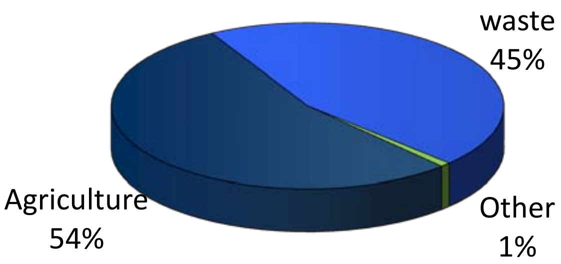

Figure 2.6 Distribution of CH_4 emissions by source in 2008

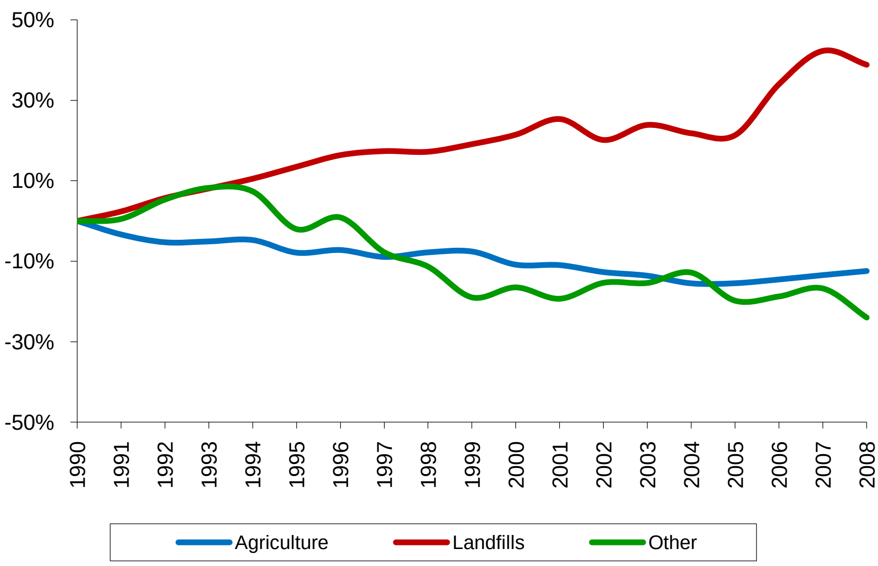

Figure 2.7 Percentage changes in emissions of CH_4 by major sources 1990 – 2008, compared to 1990

2.2.3 **Nitrous oxide (N_2O)**

Nitrous oxide emissions have increased by 5% since 1990. Agriculture accounts for around 79% of N_2O emissions in Iceland, as can be seen from Table 2.6 and Figure 2.8, with agricultural soils as the most prominent contributor. The second most important source is road transport, which increased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995.

The increase in emissions from road transport was partially counteracted by the closure of a fertilizer production facility in 2001. Emissions from agriculture decreased after 1990 because of decrease in animal livestock, but increased again after 2006 due to increased use of synthetic fertilizers.

Table 2.6 Emissions of N_2O by sector 1990 – 2008, CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Agriculture	283	277	296	256	283	302	315
Road traffic	5	12	29	38	40	41	39
Other	84	81	63	46	44	45	42
Total	**377**	**370**	**388**	**339**	**367**	**388**	**396**

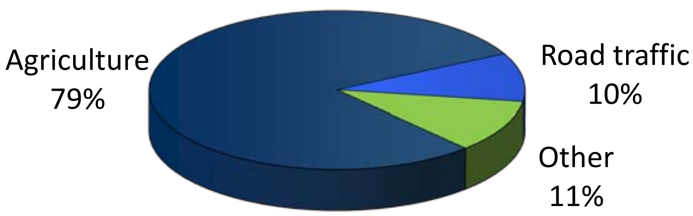

Figure 2.8 Distribution of N_2O emissions by source in 2008

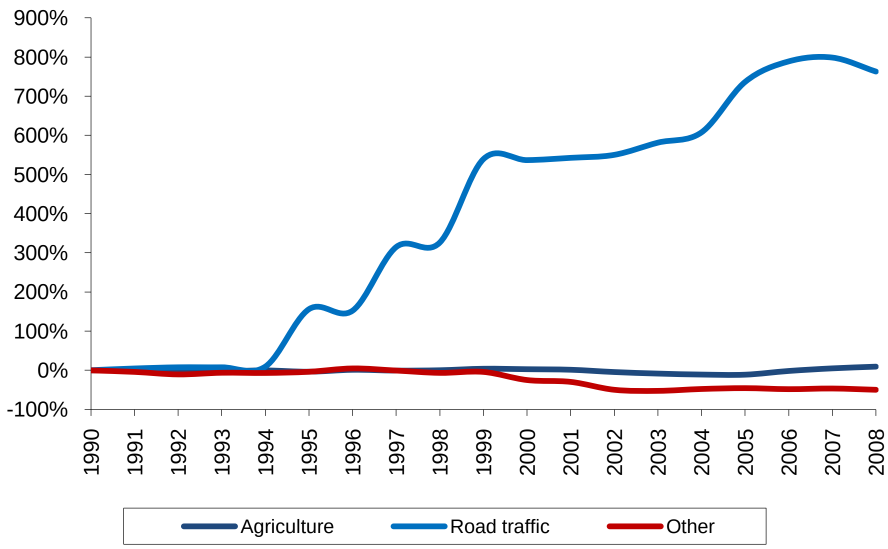

Figure 2.9 Changes in N_2O emission for major sources between 1990 and 2008

2.2.4 **Perfluorocarbons (PFCs)**

The emissions of the perfluorocarbons, i.e. tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6) from the aluminium industry were 295 and 54 Gg CO_2-equivalents respectively in 2008.

Total PFC emissions decreased by 17% in the period of 1990 – 2008. The emissions decreased steadily from 1990 to 1996 with the exception of 1995, as can be seen from Figure 2.10. PFC emissions per tonne of aluminium are generally high during start up and usually rise during expansion. The emissions therefore rose again due to the expansion of the Rio Tinto Alcan aluminium plant in 1997 and the establishment of the Century Aluminium plant in 1998. The emissions showed a steady downward trend between 1998 and 2005. The PFC reduction was achieved through improved technology and process control and led to a 98% decrease in the amount of PFC emitted per tonne of aluminium produced during the period of 1990 to 2005. The PFC emissions rose significantly in 2006 due to an expansion of the Century Aluminium facility. The extent of the increase can be explained by technical difficulties experienced during the expansion. PFC emissions per tonne of aluminium remained high at the Century Aluminium plant in 2007 and 2008, although not as high as in 2006. The Alcoa Fjarðaál aluminium plant was established in 2007 and reached full production capacity in 2008.

Table 2.7 Emissions of PFCs 1990 – 2008, CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
CF_4	355	50	108	22	282	238	295
C_2F_6	65	9	20	4	51	43	54
Total	420	59	127	26	333	281	349

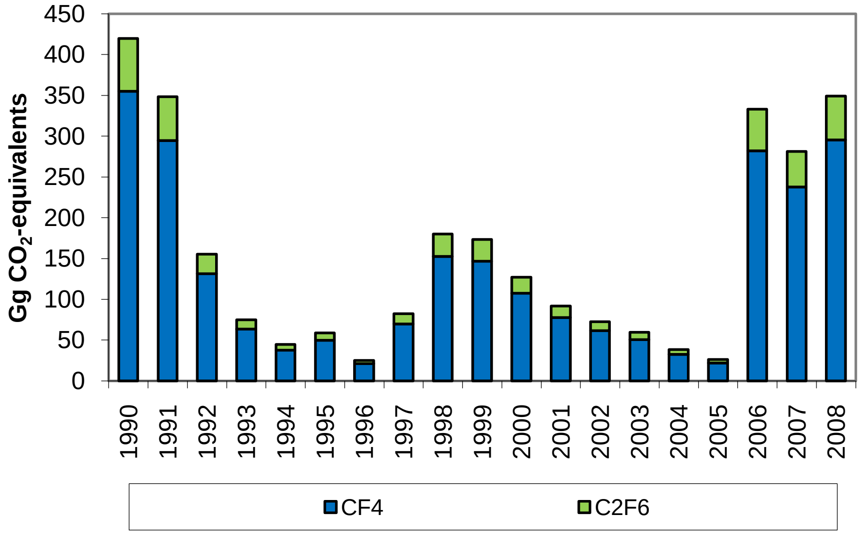

Figure 2.10 Emissions of PFCs from 1990 to 2008, Gg CO_2-equivalent

2.2.5 Hydrofluorocarbons (HFCs)

The total actual emissions of HFCs, used as substitutes for ozone depleting substances, amounted to 67 Gg CO_2-eq in 2008. The imports of HFCs started in 1992 and have increased since then in response to the phase-out of CFCs and HCFCs. Refrigeration is by far the largest source of HFCs emissions while air conditioning systems in cars are a minor source that is gradually increasing.

Table 2.8 Emissions of HFCs 1990 – 2008, Gg CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
HFC 32	-	-	-	0.1	0.1	0.1	0.1
HFC 125	-	1.6	10.8	18.3	19.2	20.5	23.0
HFC 134a	-	1.2	5.0	10.1	10.8	13.9	15.4
HFC 143a	-	1.5	11.6	20.0	21.4	23.3	28.2
HFC 152a	-	-	0.1	0.06	0.06	0.05	0.05
Total	**-**	**4.3**	**27.4**	**48.4**	**52.1**	**58.5**	**66.8**

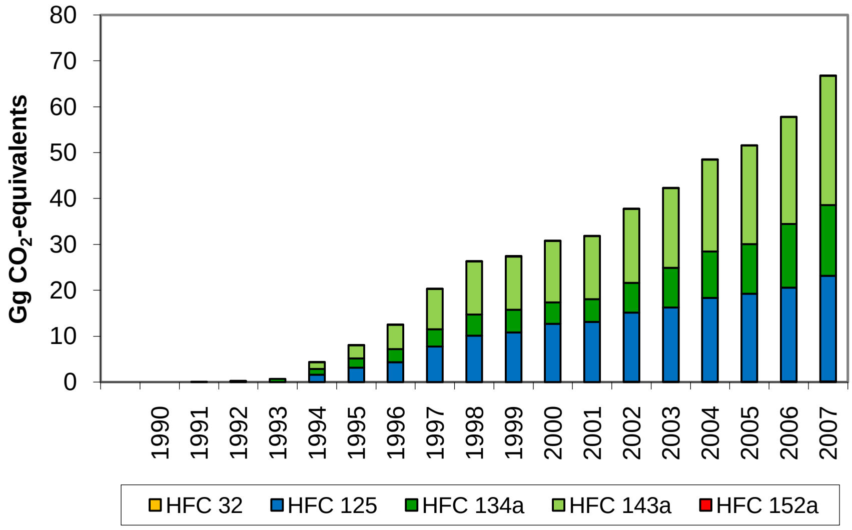

Figure 2.11 Actual emissions of HFCs 1990 – 2008, Gg CO_2-eq

2.2.6 Sulphur hexafluoride (SF_6)

The largest source of SF_6 emissions is leakage from electrical equipment. Total emissions in 2008 were 6 Gg CO_2-eq. Emissions have varied between 1 to 11 in the years between 1990 and 2008. Peaks in emissions occur during power plant construction.

A large fluctuation is seen in SF_6 emission. This is due to the leakages that occur during the installation of new distribution systems and expansion of older systems. Emissions of 11 Gg CO_2 equivalents occurred in 1999 when two large power stations were built and enlarged (Sultartangi and Búrfell) (Figure 2.12) Average emission in 1990 to 2008 equal 3 Gg CO_2-eq.

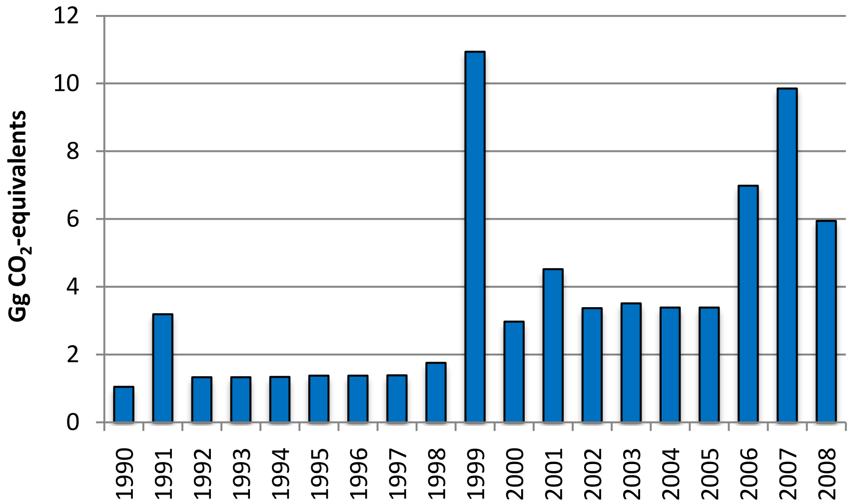

Figure 2.12 Emissions of SF_6 from 1990 to 2008

The development of the Blanda power project began in 1984 and the first generating unit went online in the autumn of 1991. This can be seen as a peak in Figure 2.12. In following years expansion took place in the metal production sector, which called for increased electricity production. The power plants at Blanda and Búrfell were expanded and new plants were constructed at Sultartangi and Vatnsfell in southern Iceland. In 2002 construction began on Kárahnjúkar hydropower project.

2.3 Emission trends by source

The energy sector is the largest contributor of greenhouse gas emissions (without LULUCF) in Iceland, followed by industrial processes, agriculture, waste and solvent and other product use. The contribution of the energy sector to the total net emissions decreased from 52% in 1990 to 43% in 2008. The contribution of industrial processes was 25% in 1990 and 41% in 2008.

Table 2.9 Total emissions of GHG by sources (without LULUCF) in 1990 – 2008, CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Energy	1783	1919	2053	2102	2179	2234	2092
-Fuel combustion	1717	1837	1890	1978	2022	2083	1906
-Geothermal energy	67	82	163	123	156	152	185
Industrial processes	863	535	946	917	1334	1484	1992
Solvent and other product use	14	14	15	16	9	12	9
Agriculture	575	542	552	498	528	551	566
Waste	180	194	201	194	213	226	221
Total without LULUCF	**3415**	**3204**	**3766**	**3727**	**4263**	**4508**	**4880**

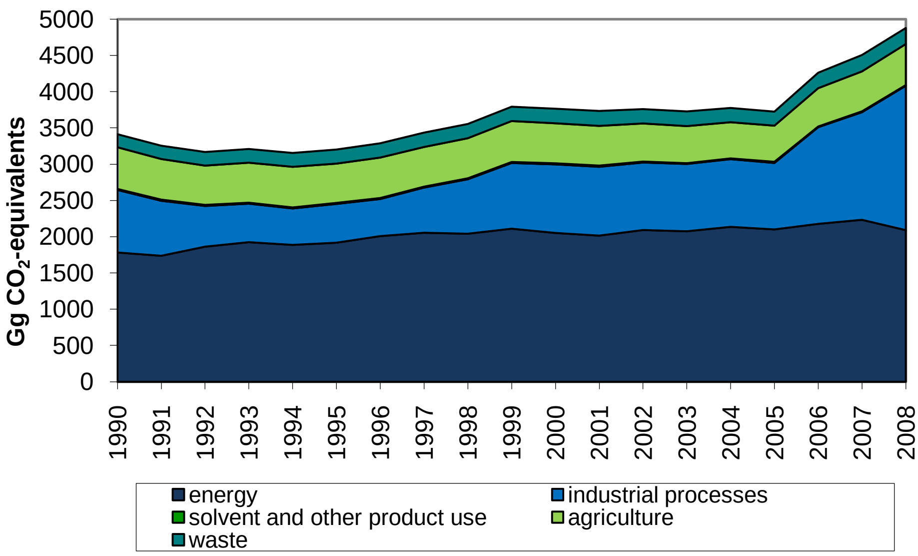

Figure 2.13. Emissions of GHG by sector from 1990 to 2008

The distribution of the total greenhouse gas emissions over the UNFCCC sectors (excluding LULUCF) in 2008 is shown in Figure 2.14.

Emissions from the energy sector account for 43% (fuel combustion 39% and geothermal energy 4%) of the national total emissions, industrial processes account for 41% and agriculture for 12%. The waste sector accounts for 4% and solvent and other product use for 0.2%.

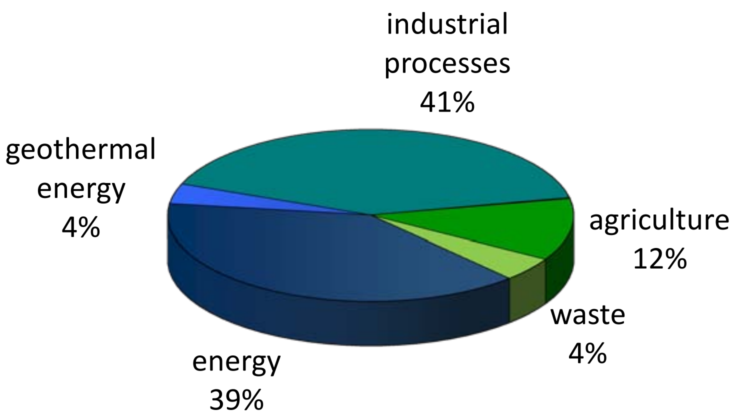

Figure 2.14 Emissions of greenhouse gases by UNFCCC sector in 2008

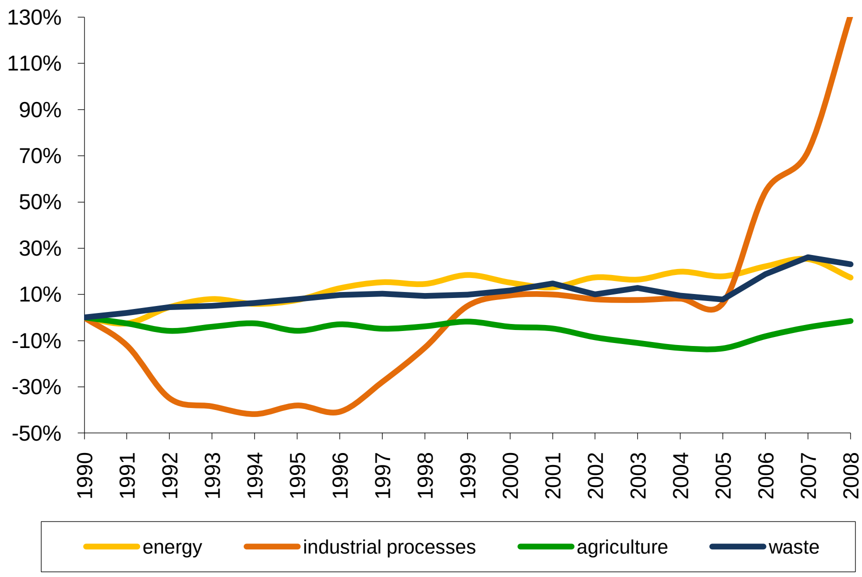

Figure 2.15 Percentage changes in emissions of total greenhouse gas emissions by UNFCCC source categories during the period 1990 – 2008, compared to 1990

2.3.1 Energy

The energy sector in Iceland is unique in many ways. Iceland ranks 1st among OECD countries in the per capita consumption of primary energy. In 2008 the consumption was about 840 GJ. However, the proportion of domestic renewable energy in the total energy budget is nearly 80%, which is a much higher share than in most other countries. The cool climate and sparse population calls for high energy use for space heating and transport. Also, key export industries such as fisheries and metal production are energy-intensive. The metal industry used around 77% of the total electricity produced in Iceland in 2008. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production

(24.5% of the electricity) and on hydropower for electricity production (75.5% of the electricity).

The development of the energy sources in Iceland can be divided into three phases. The first phase covered the electrification of the country and harnessing the most accessible geothermal fields, mainly for space heating. In the second phase, steps were taken to harness the resources for power-intensive industry. This began in 1966 with the signing of agreements on the building of an aluminium plant, and in 1979 a ferrosilicon plant began production. In the third phase, following the oil crisis of 1973-1974, efforts were made to use domestic sources of energy to replace oil, particularly for space heating and fishmeal production. Oil has almost disappeared as a source of energy for space heating in Iceland, and domestic energy has replaced oil in industry and in other fields where such replacement is feasible and economically viable.

2.3.1.1 Fuel combustion

The total emissions of greenhouse gases from fuel combustion in the energy sector over the period 1990 to 2008 are listed in Table 2.10. Figure 2.16 shows the distribution of emissions in 2008 by different source categories. The percentage change in the various source categories in the energy sector between 1990 and 2008, compared with 1990, are illustrated in Figure 2.17.

Table 2.10 Total emissions of GHG from the fuel combustion in the energy sector in 1990 – 2008, CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Energy industries	13	19	10	13	15	30	15
Manufacturing ind./constr.	377	379	450	454	433	426	367
Transport	621	628	674	849	994	1029	974
Other sectors	706	810	756	663	580	598	523
- **Thereof fishing**	662	780	728	633	555	571	523
Total	**1717**	**1837**	**1890**	**1978**	**2022**	**2083**	**1906**

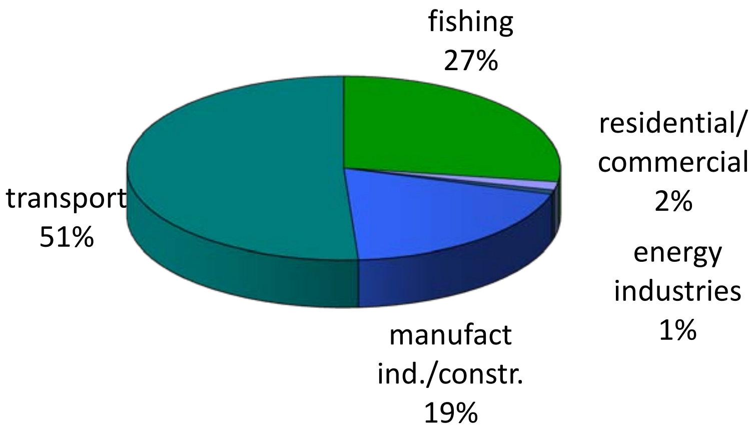

Figure 2.16 Greenhouse gas emissions in the fuel combustion sector 2008, distributed by source categories

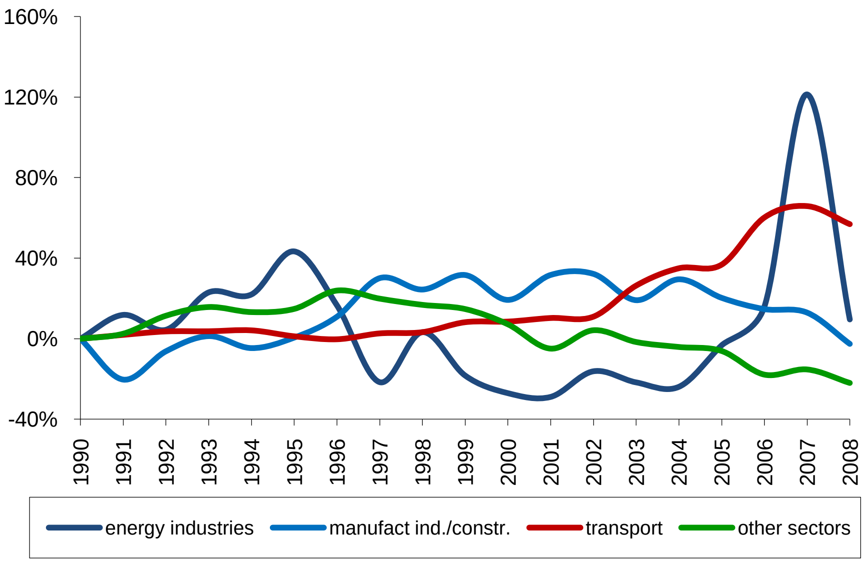

Figure 2.17 Percentage changes in emissions in various source categories of fuel combustion in the energy sector during the period 1990 – 2008, compared to 1990

Table 2.10 and Figure 2.17 show that emissions from transport have increased as emissions from other sector (dominated by fishing) have decreased. Emissions from energy industries and from manufacturing industries are back to 1990 levels.

Energy industries include emissions from electricity and heat production. Iceland relies heavily on renewable energy sources for electricity and heat production, thus emissions from this sector are low. Emissions from energy industries accounted for 0.8% of the sector’s total and 0.3% of the total GHG emissions in Iceland in 2008. Electricity is produced with fuel combustion at 3 locations, which are located far from the distribution system. Some generation facilities have back up fuel combustion which they use if problems occur in the distribution system. Some district heating facilities that lack access to geothermal energy sources use electric boilers to produce heat from electricity. They depend on curtailable energy. These heat plants have back-up fuel combustion in case of an electricity shortage or problems in the distribution system. Emissions from the energy industries sector have generally decreased since 1990. In 1995 there were issues in the electricity distribution system that resulted in higher emissions that year. Unusual weather conditions during the winter of 1997/1998 led to unfavourable water conditions for the hydropower plants. This created a shortage of electricity which was met by burning oil for electricity and heat production. In 2007 a new aluminium plant was established. Because the Kárahnjúkar hydropower project was delayed, the aluminium plant was supplied for a while with electricity from the distribution system. This led to electricity shortages for the district heating systems depending on curtailable energy, leading to increased fuel combustion and emissions.

Increased emissions from the Manufacturing Industries and Construction source category over the period 1990 to 2007 are explained by the increased activity in the construction sector during the period. The knock-off effect of the increased levels of economic growth was increased activity in the construction sector. Emissions have risen, particularly in recent years (until 2007), related to the construction of Iceland's largest hydropower plant (Kárahnjúkar). The construction sector collapsed in fall 2008 due to the economic crises. Emissions from the sector decreased by 4% between 2007 and 2008. The fishmeal industry is the second most important source within manufacturing industries and construction. Emissions from fishmeal production decreased over the period due to replacement of oil with electricity as well as less production.

The fisheries dominate the Other Sector. Emissions from fisheries rose from 1990 to 1996 because a substantial portion of the fishing fleet was operating in unusually distant fishing grounds. From 1996, the emissions decreased again reaching 1990 levels in 2001. Emissions increased again by 10% between 2001 and 2002. In 2003 emissions again reached the 1990 level. In 2008 emissions were 21% below the 1990 level. Annual changes are inherent to the nature of fisheries.

The vehicle fleet in Iceland has increased by nearly 81% since 1990. This has led to increased emissions from the road transport sector (63%). The latest trend has been towards large passenger cars, which consume more fuel. Fuel prices rose significantly in 2008 leading to lower emissions (6%) from the sector compared to the previous year. A decrease in navigation and aviation has compensated for rising emissions in the transport sector to some extent.

2.3.1.2 Geothermal energy

Iceland relies heavily on geothermal energy for space (heating 90% of the homes) and electricity production (24.5% of the total electricity production). The emissions from geothermal power plants are considerably less than from fossil fuel power plants. Table 2.11 shows the emissions from geothermal energy from 1990 to 2008.

Electricity production using geothermal power increased during this period from 283 to 4038 GWh.

Table 2.11 Emissions from geothermal energy from 1990 – 2008, CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Geothermal energy	67	82	163	123	156	152	185

2.3.2 Industrial processes

Production of raw materials is the main source of industrial process related emissions for both CO_2 and other greenhouse gases such as N_2O and PFCs. The industrial process sector accounts for 41% of the national greenhouse gas emissions. As can be seen in Figure 2.18 and Table 2.12, emissions from industrial processes decreased from 1990 to 1996, mainly because of a decrease in PFC emissions. Increased production capacity has led to an increase in industrial process emissions since 1996.

Table 2.12 Emissions from industrial processes 1990 – 2008, CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Mineral products	52	38	66	56	63	65	63
Chemical industry	49	43	19	-	-	-	-
Metal production	761	449	831	809	1212	1352	1857
-Ferroalloys	205	239	358	374	372	391	340
-Aluminium	556	210	473	435	840	961	1517
-Aluminium CO_2	136	151	346	409	507	680	1168
-Aluminium PFC	420	59	127	26	333	281	349
Consumption of HFCs and SF_6	1	6	30	52	59	68	73
Total	863	535	946	917	1334	1484	1992
Emissions fulfilling 14/CP.7							**1163**

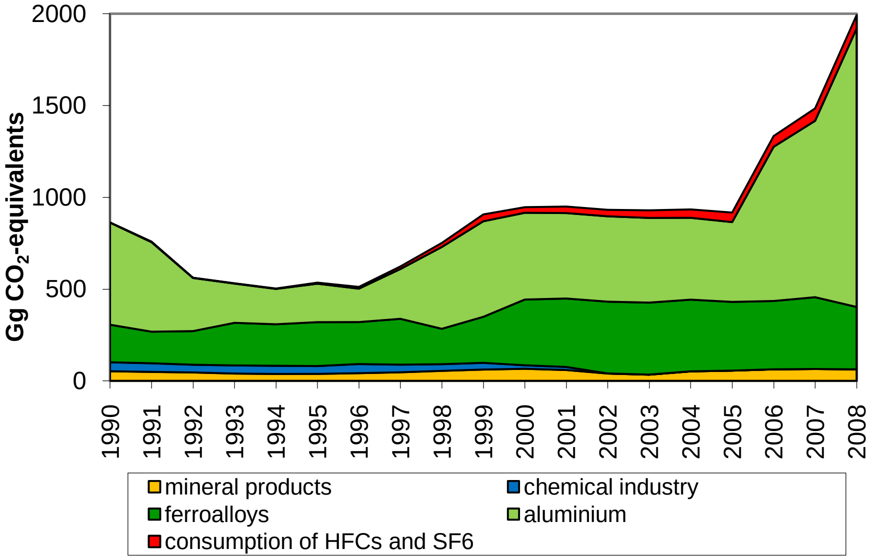

Figure 2.18 Total greenhouse gas emissions in the industrial process sector during the period from 1990 – 2008, Gg CO_2-eq.

The most significant category within the industrial processes sector is metal production, which accounted for 86% of the sector's emissions in 1990 and 93% in 2008. Aluminium production is the main source within the metal production category, accounting for 76% of the total industrial processes emissions. Aluminium is produced at three plants, Rio Tinto Alcan at Straumsvík, Century Aluminium at Grundartangi and Alcoa Fjarðaál at Reyðarfjörður. The production technology in all aluminium plants is based on using prebaked anode cells. The main energy source is electricity, and industrial process CO_2 emissions are mainly due to the anodes that are consumed during the electrolysis. In addition, the production of aluminium gives rise to emissions of PFCs. From 1990 to 1996 PFC emissions were reduced by 94%. Because of the expansion of the existing aluminium plant in 1997 and the establishment of a second aluminium plant in 1998, emissions increased again from 1997 to 1999. From 2000, the emissions showed a steady downward trend until 2005. The PFC reduction was achieved through improved technology and process control and led to a 98% decrease in the amount of PFC emitted per tonne of aluminium produced during the period of 1990 to 2005; from 4.78 tonnes CO_2-equivalents in 1990 to 0.10 tonnes CO_2-equivalents in 2005. In 2006 the PFC emissions rose significantly due to an expansion at Century Aluminium. The extent of the increase can be explained by technical difficulties experienced during the expansion. PFC emissions remained high per tonne of aluminium at the Century Aluminium plant in 2007and 2008, although not as high as in 2006. The Alcoa Fjarðaál aluminium plant was established in 2007 and reached full production capacity in 2008. PFC emissions per tonne of aluminium are generally high during start up and usually rise during expansion. The amount of PFC emitted per tonne of aluminium was 0.45 tonnes of CO_2-equivalents in 2008.

Production of ferroalloys is another major source of emissions, accounting for 17% of industrial processes emissions in 2008. CO_2 is emitted due to the use of coal and coke as reducing agents and from the consumption of electrodes. In 1998 a power shortage caused a temporary closure of the ferroalloy plant, resulting in exceptionally low emissions that year. In 1999, however, the plant was expanded and emissions have therefore increased considerably, or by 66% since 1990. Emissions in 2008 were 13% lower than in 2007, owing to less production due to reconstruction of one of the three ovens at the Elkem ferrosilicon plant.

Production of minerals is the sector's second most important category, accounting for 3% of the emissions in 2008. Cement production is the dominant contributor. Cement is produced in one plant in Iceland, emitting CO_2 derived from carbon in the shell sand used as the raw material in the process. Emissions from the cement industry reached a peak in 2000 but declined until 2003, partly because of cement imports. In 2004 to 2007 emissions increased again because of increased activity related to the construction of the Kárahnjúkar hydropower plant (built 2002 to 2007) although most of the cement used for the project was imported. Emissions in 2008 were 4% lower than in 2007.

Production of fertilizers which used to be the main contributor to the process emissions from the chemical industry was closed down in 2001. No chemical industry has been in operation in Iceland after the closure of silicon production facility in 2004.

Imports of HFCs started in 1992 and have increased since then as they are used as substitutes of ozone depleting substances that are being phased out in accordance with the Montreal Protocol. Refrigeration is by far the largest part of HFCs and emissions from air cooling system in cars are increasing.

The largest source of SF_6 emissions is leakages from electrical equipment. Emissions have varied between 1 to 11 Gg from 1990 to 2008, peaking in years when new power plants were built (Figure 2.12).

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 are regarded as indirect greenhouse gases. The NMVOC compounds are oxidized to CO_2 in the atmosphere over time and the magnitude of the formation of CO_2 was estimated. Also included in this sector are emissions of N_2O, which occur because of its uses mainly for medical purposes, and also to a smaller extent for car racing. NMVOC emissions were 9 Gg CO_2-equivalents in total in 2008, which is 36% below the 1990 level.

The dominant part of emission in the solvent and other product use sector is from Other, where N_2O emissions from anesthesia is the main source (Figure 2.19).

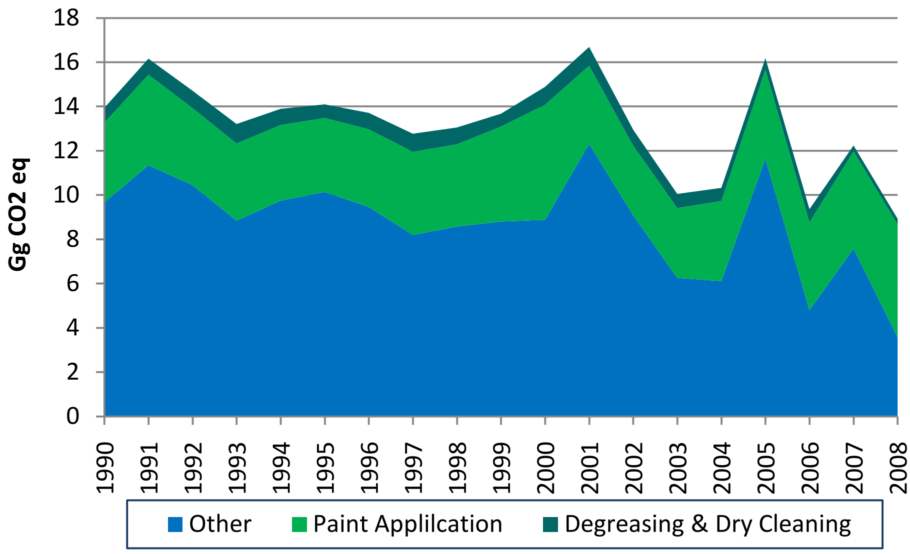

Figure 2.19 NMVOC emission from 1990 - 2008

2.3.4 **Agriculture**

Emissions from agriculture decreased from 1990 to 2005, as can be seen in Table 2.13 and Figure 2.20. This change was mainly due to a decreasing number of livestock. Emissions rose again from 2006 to 2008 due to increased use of synthetic fertilizers.

Table 2.13 Total greenhouse gas emissions from agriculture in 1990 – 2008, Gg CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Enteric fermentation	265	243	235	223	225	228	231
Manure management	54	51	50	47	48	49	49
Agricultural soils	256	248	267	228	255	274	287
Total	**575**	**542**	**552**	**498**	**528**	**551**	**566**

The largest sources of agricultural greenhouse gas emissions are methane from enteric fermentation and nitrous oxide emissions from agricultural soils. Greenhouse gas emissions from the agricultural sector accounted for 12% of the overall greenhouse gas emissions in 2008.

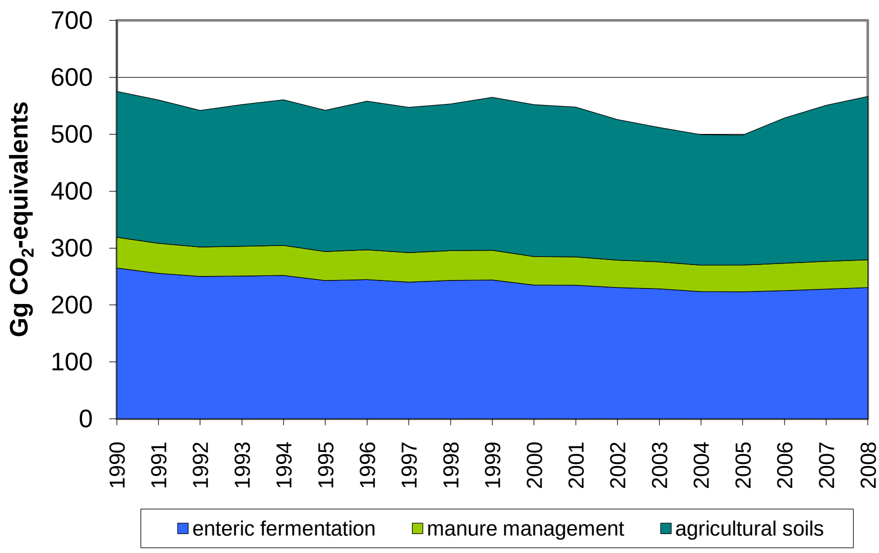

Figure 2.20 Total greenhouse gas emissions from agriculture 1990 – 2008, Gg CO_2-eq.

2.3.5 **LULUCF**

Emissions from the LULUCF sector in Iceland are high compared to other sectors. A large part (79%) of the emissions from the sector in 2008 was due to drainage of organic soil for different land uses. The emissions can be attributed to drainage of wetlands in the latter half of the 20th century, which had largely ceased by 1990. Emissions of CO_2 from drained wetlands continue for a long time after drainage.

The time series in the LULUCF sector are incomplete. Trend analysis can therefore only be done provisionally. Time series are only available for few categories, i.e. Forest land, Revegetation (Other land converted to Grassland) and Flooded land. The changes reported for other categories are due to adjustments in area resulting from the available time series. Net emissions (emissions – removals) in the sector have decreased over the time period, as can be seen in Table 2.14. This is explained by increased removals through forestry and revegetation as well as a small decline in emissions from drained wetlands, resulting from adjustment in area toward increased forest land. Increased removals in Forestry and Revegetation are explained by the increased activity in those sectors and changes in forest growth with stand age. The reason for decrease in emissions from drained wetland is that part of the previously drained area has been converted to Forest Land. The increase in emissions from Wetlands is due to increased emissions from hydropower reservoirs as new reservoirs were created during the time period. An increase in emissions from hydropower reservoirs (by 74%) can be seen from 2006 to 2007 when the Kárahnjúkar Hydropower Plant was established. Emissions from Wetlands in 2006 that are not stemming from hydropower reservoirs were due to a single wild-fire event reported that year.

Table 2.14 Emissions from the LULUCF sector from 1990 – 2008, Gg CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Forest Land	-19	-37	-64	-100	-112	-122	-134
Cropland	992	992	992	995	995	997	997
Grassland	1081	1027	943	854	835	820	805
- Wetland converted to Grassland	1362	1359	1355	1354	1353	1353	1353
- Revegetation	-280	-332	-412	-499	-518	-534	-548
Wetland	4	14	17	17	19	30	30
- Hydropower reservoirs	4	14	17	17	17	30	30
Settlement	NE	NE	NE	0	0	0	NO
Other emissions	298	298	297	299	299	297	298
- Wetland converted to Grassland (N_2O)	296	295	295	294	294	294	294
- Other emissions due to Revegetation	2	2	2	5	5	3	5
LULUCF Total	**2356**	**2292**	**2185**	**2066**	**2038**	**2021**	**1997**

Analyses of trends in emissions of the LULUCF sector must be interpreted with care as time series are missing for many factors and potential sinks or sources are not included. Uncertainty estimates for reported emissions are quantitative only in few cases and observed changes in reported emissions therefore not necessarily significantly different from zero.

Iceland has elected revegetation as an activity under Article 3.4 of the Kyoto Protocol. Removals from revegetation amounted to 269 Gg (Net – Net accounting) in 2008. Removals from activities under Articles 3.3 (Afforestation and Reforestation) amounted to 102 Gg in 2008, and the reminder, 32 Gg, was due to C-stock increase in older forests.

2.3.6 **Waste**

The amount of greenhouse gases (CH_4) from landfills increased steadily from 1990 to 2001, as can be seen in Table 2.15 and Figure 2.21. A minor decrease in emissions occurred between 2002 and 2005, but emissions increased again in 2006 and 2007. The emissions rose by 51% from 1990 to 2007. There are two reasons for this, increasing amounts of waste being landfilled instead of incineration and a larger percentage of waste being landfilled in managed waste disposal sites. The amount of waste being landfilled increased by 28% from 1990. Methane recovery started at the largest operating landfill site in 1997, and the amount recovered increased steadily until 2006 when methane recovery equipment failed partly due to technical problems. These problems led to continued failure in methane recovery in 2007. A significant downswing is seen in waste generation in 2008, which can be attributed to the financial crisis that hit Iceland that year. Methane recovery was in better function in 2008 but significantly less methane was recovered than prior to the equipment failure.

Table 2.15 Emissions from the waste sector from 1990 – 2008, Gg CO_2-eq.

	1990	1995	2000	2005	2006	2007	2008
Landfills	134	151	164	167	186	200	196
Wastewater handling	20	25	26	25	25	23	23
Waste incineration	26	17	10	1	1	1	1
Composting	-	0.4	0.4	0.9	1.4	1.8	1.8
Total	**180**	**194**	**201**	**194**	**213**	**226**	**221**

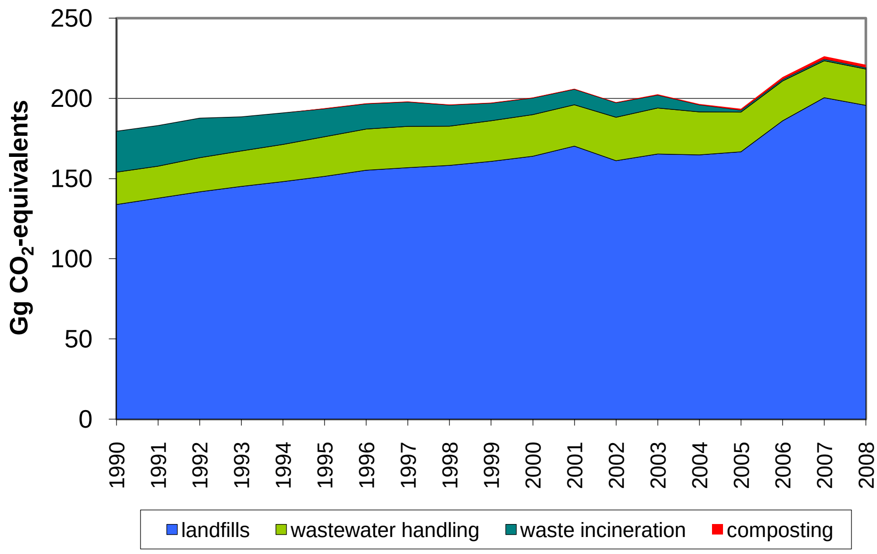

Figure 2.21 Emissions of greenhouse gases in the waste sector 1990 – 2008, Gg CO_2-eq.

Fluctuations seen in wastewater emissions are mainly due to Industrial wastewater where the fishing industry plays the main role. Emissions from Domestic wastewater are a minor factor in total wastewater emissions. Emissions from Domestic wastewater handling have increased consistently since 1990 because the total number of inhabitants connected to wastewater facilities has increased in the time period. A small decrease is seen in Domestic wastewater handling in 2007 when a municipality near Reykjavík was incorporated into Reykjavik's wastewater treatment that is an aerobic treatment leading to a decrease in emission from that municipality as the prior treatment was semi-anaerobic.

The fish industry is the dominant emitting factor in Industrial Wastewater handling in Iceland. The CH_4 emissions from fish industry alone were four to seven times larger than from dairy products and meat & poultry production aggregated in the period from 1990 to 2008. See Figure 2.22.

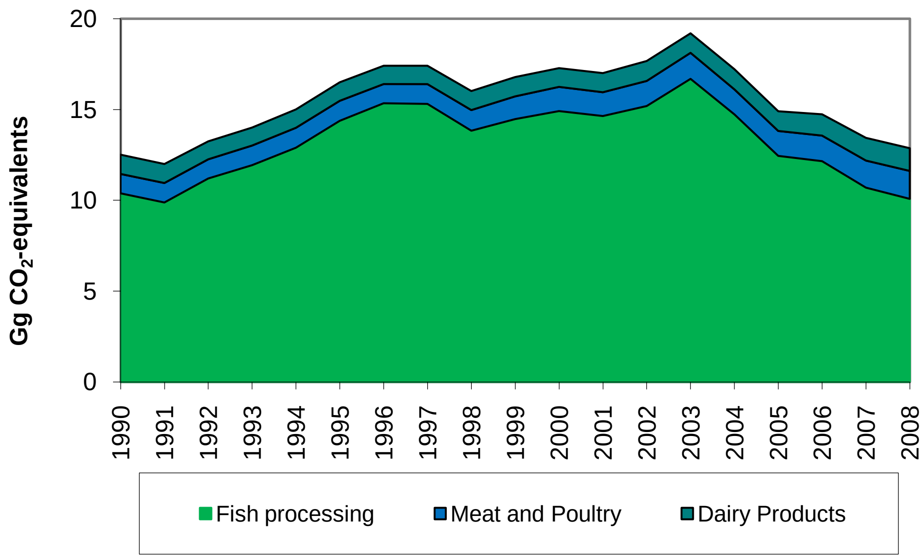

Figure 2.22 Methane emissions of industrial wastewater sections

Emissions from waste incineration have decreased consistently since 1990 because the total amount of waste being incinerated in Iceland has decreased. A higher percentage of the waste has concurrently been incinerated with energy recovery and is thus reported under 1A1a (public electricity and heat production) and 1A4a (commercial and institutional heat production).

2.3.7 International bunkers

Emissions from international aviation and marine bunker fuels are excluded from national totals as is outlined in the IPCC Guidelines. These emissions are presented separately for information purposes and can be seen in Table 2.16.

In 2008, greenhouse gas emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 663 Gg CO_2-equivalents, which corresponds to about 14% of the total Icelandic greenhouse gas emissions. Greenhouse gas emissions from marine and aviation bunkers increased by around 106% from 1990 to 2008; with a 6% decrease between 2007 and 2008.

Looking at these two categories separately, it can be seen that greenhouse gas emissions from international marine bunkers increased by 131% from 1990 to 2008, while emissions from aircrafts increased by 95% during the same period. Between 2007 and 2008 emissions from marine bunkers increased by 10% while emissions from aviation bunkers decreased by 16%. Foreign fishing vessels dominate the fuel consumption from marine bunkers.

Table 2.16 Greenhouse gas emissions from international aviation and marine bunkers, Gg CO_2-eq.

	1990	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**
Marine	100	146	221	112	139	209	231
Aviation	222	238	411	425	504	516	432
Total	**322**	**384**	**632**	**537**	**643**	**725**	**663**

2.4 Emission trends for indirect greenhouse gases and SO_2

Nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) have an indirect effect on climate through their influence on greenhouse gases, especially ozone. Sulphur dioxide (SO_2) affects climate by increasing the level of aerosols that have in turn a cooling effect on the atmosphere.

2.4.1 Nitrogen oxides (NOx)

The main sources of nitrogen oxides in Iceland are fishing, transport and the manufacturing industry and construction, as can be seen in Figure 2.23,. The NOx emissions from fishing rose from 1990 to 1996 when a substantial portion of the fishing fleet was operating in distant fishing grounds. From 1996 emissions decreased, reaching the 1990 levels in 2001. Emissions in 2008 were 21% below the 1990 level. Annual changes are inherent to the nature of fisheries. Emissions from transport are dominated by road transport. These emissions have decreased rapidly (by 17%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 63%. The rise in emissions from the manufacturing industries and construction are dominated by increased activity in the construction sector during the period. Total NOx emissions, like the emissions from fishing, increased until 1996 and decreased thereafter until 2001. Emission rose again between 2002 and 2004 and then decreased again. The emissions in 2008 were 14% below the 1990 level.

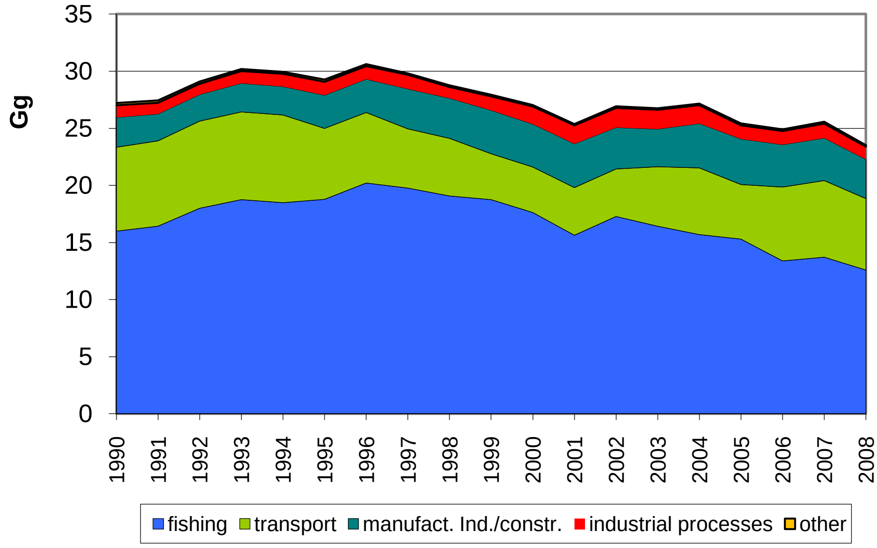

Figure 2.23 Emissions of NOx by sector 1990 – 2008, Gg.

2.4.2 **Non-methane volatile organic compounds (NMVOC)**

The main sources of non-methane volatile organic compounds are transport and solvent use, as can be seen in Figure 2.24. Emissions from transport are dominated by road transport. These emissions decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Emissions from solvent use have varied between 2 Gg and 4 Gg since 1990 with no obvious trend. The total emissions show a downward trend from 1994 to 2008. The emissions in 2008 were 55% below the 1990 level.

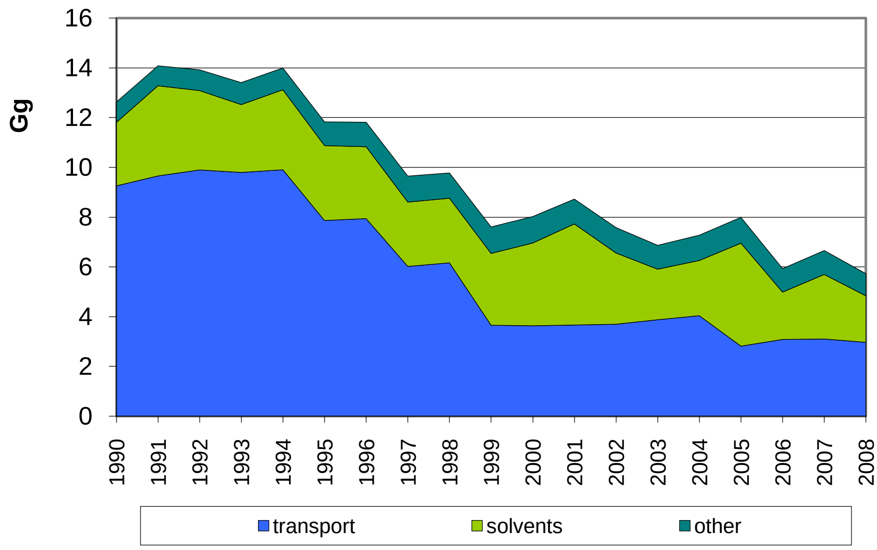

Figure 2.24 Emissions of NMVOC by sector 1990 – 2008, Gg.

2.4.3 **Carbon monoxide (CO)**

Transport is the most prominent contributor to CO emissions in Iceland, as can be seen in Figure 2.25. Emissions from transport are dominated by road transport. These emissions have decreased rapidly after the use of catalytic converters in all new vehicles became obligatory in 1995. Total CO emissions show, like the emissions from transport, a rapid decrease after 1990. The emissions in 2008 were 57% below the 1990 level.

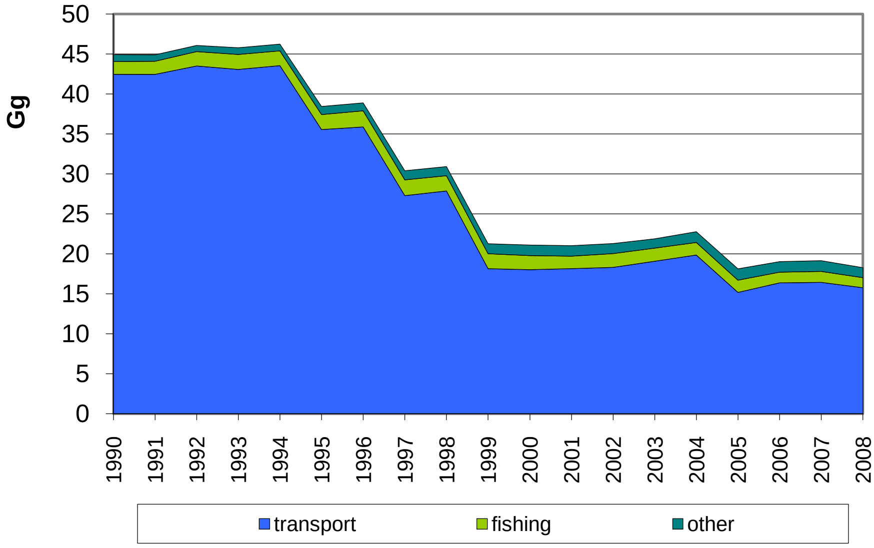

Figure 2.25 Emissions of CO by sector 1990 – 2008, Gg.

2.4.4 **Sulphur dioxide (SO_2)**

Geothermal energy exploitation is by far the largest source of sulphur emissions in Iceland. Sulphur emitted from geothermal power plants is in the form of H_2S. Emissions have increased by 370% since 1990 due to increased activity in this field. Other significant sources of sulphur dioxide in Iceland are industrial processes and manufacturing industry and construction, as can be seen in Figure 2.26. Emissions from industrial processes are dominated by metal production. Until 1996 industrial process sulphur dioxide emissions were relatively stable. Since then, the metal industry has expanded. In 1990, around 88,000 tonnes of aluminium were produced at one plant and around 63,000 tonnes of ferroalloys at one plant, Elkem Iceland. In 2008 around 781,151 tonnes of aluminium were produced at three plants and around 96,000 tonnes of ferroalloys were produced at Elkem Iceland. This led to increased emissions of sulphur dioxide. The fishmeal industry is the main contributor to sulphur dioxide emissions from fuel combustion in the sector Manufacturing industries and construction. Emissions from the fishmeal industry increased from 1990 to 1997 but have declined since; the emissions were 58% below the 1990 level in 2008.

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

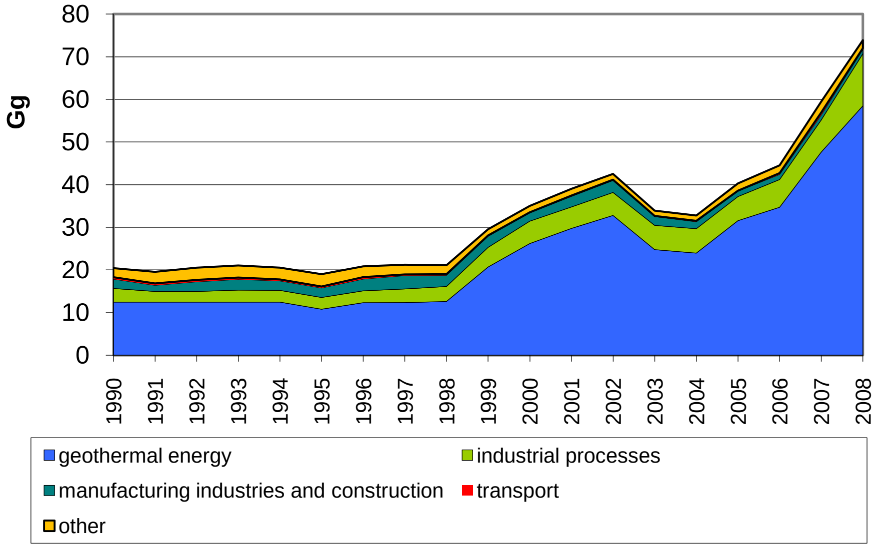

Figure 2.26 Emissions of SO_2 by sector 1990 – 2008, Gg.

3 ENERGY

3.1 Overview

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

The energy sector accounts for 43% (fuel combustion 39%, geothermal energy 4%) of the GHG emissions in Iceland. Energy related emissions increased by 17% from 1990 to 2008. From 2007 to 2008 the emissions from fuel combustion decreased by 8%, while emissions from geothermal energy increased by 22%. Total emissions related to energy decreased by 6% from 2007 to 2008. Fisheries and road traffic are the sector's largest single contributors. Combustion in manufacturing industries and construction is also an important source. Recalculations were made for road transport for the current 2010 submission.

3.1.1 Methodology

Emissions from fuel combustion activities are estimated at the sectoral level based on the methodologies suggested by the IPCC Guidelines and the Good Practice Guidance. They are calculated by multiplying energy use by source and sector with pollutant specific emission factors. Activity data is provided by the National Energy Authority (NEA), which collects data from the oil companies on fuel sales by sector. The sales statistics for the manufacturing industry are given for the sector as a total. They do not specify the fuel consumption by the different industrial sources. This division is made by EA on basis of the reported fuel use by all major industrial plants (metal production, cement) and from green accounts. Fuel combustion activities are divided into two main categories; stationary and mobile combustion. Stationary combustion includes Energy Industries, Manufacturing industries and a part of the Other sectors (residential and commercial/institutional sector). Mobile combustion includes Civil Aviation, Road Transport, Navigation, Fishing (part of the Other sectors), mobile combustion in Construction (part of Manufacturing Industries and Construction sector) and International bunkers.

3.1.2 **Key source analysis**

The key source analysis performed for 2008 has revealed, as indicated in Table 1.1, that in terms of total level and/or trend uncertainty the key sources in the Energy sector are the following:

- 1A2, Manufacturing Industries and Construction – CO_2
- 1A3(a,d), Non-Road Transport – CO_2
- 1A3b, Road Transport – CO_2 And N_2O
- 1A4(a,b), Residential/Commercial/Institutional – CO_2
- 1A4c, Fishing – CO_2
- 1B2d, Geothermal Energy – CO_2

3.1.3 **Completeness**

Table 3.1 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all sub-sources in the energy sector.

Table 3.1 Energy – completeness (E: estimated, NE: not estimated, NA: not applicable)

	Greenhouse gases						Other gases			
Sector	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
Energy industries										
Public electricity and heat production	E	E	E	NA	NA	NA	E	E	E	E
Petroleum refining	NOT OCCURRING									
Manufacture of Solid Fuels	NOT OCCURRING									
Manufacturing Industries and Construction										
Iron and Steel	E	E	E	NA	NA	NA	E	E	E	E
Non-ferrous metals	E	E	E	NA	NA	NA	E	E	E	E
Chemicals	E	E	E	NA	NA	NA	E	E	E	E
Pulp, paper and print	NOT OCCURRING									
Food Processing, Beverages and Tobacco	E	E	E	NA	NA	NA	E	E	E	E
Other	E	E	E	NA	NA	NA	E	E	E	E
Transport										
Civil Aviation	E	E	E	NA	NA	NA	E	E	E	E
Road Transportation	E	E	E	NA	NA	NA	E	E	E	E
Railways	NOT OCCURRING									
Navigation	E	E	E	NA	NA	NA	E	E	E	E
Other Transportation	NOT OCCURRING									
Other Sector										
Commercial/Institutional	E	E	E	NA	NA	NA	E	E	E	E
Residential	E	E	E	NA	NA	NA	E	E	E	E
Agriculture/Forestry/Fisheries	E	E	E	NA	NA	NA	E	E	E	E
Other	NOT OCCURRING									
Fugitive Emissions from Fuels										
Solid Fuels	NOT OCCURRING									
Oil and Natural Gas	NE	NE	NE	NA	NA	NA	NE	NE	NE	NE
Geothermal Energy	E	NA	NA	NA	NA	NA	NA	NA	NA	E
International Transport										
Aviation	E	E	E	NA	NA	NA	E	E	E	E
Marine	E	E	E	NA	NA	NA	E	E	E	E

3.1.4 Source specific QA/QC procedures

The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, estimating uncertainties, archiving information and reporting, as further elaborated in the QA/QC manual. No source specific QA/QC procedures have been developed yet for the energy sector.

3.2 Energy industries (1A1)

Energy industries include emissions from electricity and heat production. Iceland relies heavily on renewable energy sources for electricity and heat production, thus emissions from this sector are low. Emissions from energy industries accounted for 0.8% of the sectors total and 0.3% of the total GHG emissions in Iceland in 2008.

Activity data for the energy industries are provided by the NEA. The CO_2 emission factors reflect the average carbon content of fossil fuels. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and presented in Table 3.6 along with sulphur content of the fuels. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from Table 1-15 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Default EF from Tables 1-7 to 1-11 in the Reference Manual were used where EFs are missing.

3.2.1 Electricity production

Electricity was produced from hydropower, geothermal energy and fuel combustion in 2008 (Table 3.2) with hydropower as the main source of electricity. Electricity was produced with fuel combustion at three locations that are located far from the distribution system. Some public electricity plants have back up fuel combustion which they use when problems occur in the distribution system.

Table 3.2 Electricity production in Iceland. GWh.

	1990	1995	2000	2005	2006	2007	2008
Hydropower	4159	4678	6352	7014	7289	8394	12427
Geothermal	283	288	1323	1658	2631	3579	4037
Fuel combustion	6	8	4	8	5	3	3
Total	**4,447**	**4,977**	**7,679**	**8,680**	**9,925**	**11,976**	**16,467**

Activity data for fuel combustion and the resulting emissions are given in Table 3.3. The resulting emissions of GHG per kWh amount to 620 g of CO_2 per kWh.

Table 3.3 Fuel use and resulting emissions from electricity production. Gg.

	1990	1995	2000	2005	2006	2007	2008
Gas/Diesel oil	1.3	1.5	1.1	2.0	1.3	1.1	0.5
Emissions	**4.1**	**4.9**	**3.4**	**6.3**	**4.3**	**3.5**	**1.7**

Emissions from hydropower reservoirs are included in the LULUCF sector and emissions from geothermal power plants are reported in sector 1B2. Emissions from hydropower reservoirs amounted to 30 Gg of CO_2 equivalents and emissions from geothermal power plants to 185 Gg of CO_2, in 2008. The resulting emissions of GHG per kWh amount to 2.4 g/kWh for hydropower plants and to 46 g/kWh for geothermal energy. The average GHG emission from electricity production in Iceland in 2008 was thus 13.2 g/kWh.

3.2.2 Heat production

Geothermal energy was the main source of heat production in 2008. Some district heating facilities, which lack access to geothermal energy sources, use electric boilers to produce heat from electricity. They depend on curtailable energy. These heat plants have back up fuel combustion in case of electricity shortages or problems in the distribution system. Three district heating stations burn waste to produce heat and are connected to the local distribution system. Emissions from these waste incineration plants are reported under Energy Industries. A description of the method to estimate greenhouse gas emissions is given in Chapter 8.

Table 3.4 Fuel use and resulting emissions from heat production. Gg.

	1990	1995	2000	2005	2006	2007	2008
Residual fuel oil	3.0	3.1	0.1	0.2	0.1	4.5	0.1
Gas/Diesel oil	-	-	-	-	-	-	0.7
Solid waste	NO	4.7	6.0	6.0	10.8	12.0	10.5
Emissions (GHG)	**9.2**	**14.2**	**6.4**	**6.6**	**11.2**	**26.0**	**13.0**

3.3 Manufacturing industries and construction (1A2)

Emissions from the manufacturing industries and construction accounted for 18% of the sector's total and 8% of total GHG emissions in Iceland in 2008. Mobile combustion in the construction sector accounts for 58% of the total emissions from manufacturing industries and the construction sector.

3.3.1 Manufacturing industries, stationary combustion

Information about the total amount of fuel used by the manufacturing industries is obtained from the National Energy Authority. Total use of different oil products is based on the NEAs annual sales statistics on fossil fuels. There is thus a given total, which the usage in the different sectors must sum up to. Fuel consumption in the fishmeal industry from 1990 to 2002 was estimated from production statistics, but the numbers for 2003 to 2008 are based on data provided by the industry (Green Accounts). All major industries (metal and cement industries) report their fuel use to EA along with other relevant information for industrial processes. Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Emissions from fuel use in the ferroalloys production is reported und 1A2a.

Table 3.5 Fuel use and emissions from stationary combustion in the manufacturing industry. Gg.

	1990	1995	2000	2005	2006	2007	2008
Gas/Diesel oil	5.0	1.6	10.3	24.1	23.8	12.1	8.1
Residual fuel oil	55.9	56.2	46.2	25.0	23.6	22.8	19.6
LPG	0.5	0.4	0.9	0.9	1.2	1.5	1.9
Electrodes (residue)	0.8	0.3	1.5	-	-	0.5	0.5
Steam Coal	18.6	8.6	13.3	9.9	13.6	24.4	21.5
Petroleum coke	-	-	-	8.1	8.3	0.2	-
Waste oil	-	5.0	6.0	1.8	0.0	2.3	2.2
Total Emissions	**256**	**231**	**253**	**238**	**238**	**208**	**156**

The CO_2 emission factors (EF) used reflect the average carbon content of fossil fuels. They are, with exception of NCV for steam coal, which was obtained from the industry which uses the coal, taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance. They are presented in Table 3.6 along with sulphur content of the fuels.

Table 3.6 Emission factors for CO_2 from fuel combustion and S-content of fuel

	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t fuel]	S-content [%]
Kerosene (heating and aviation)	44.59	19.50	0.99	3.16	0.2
Gasoline	44.80	18.90	0.99	3.07	0.005
Gas / Diesel Oil	43.33	20.20	0.99	3.18	0.2
Residual fuel oil	40.19	21.10	0.99	3.08	1.8
Petroleum coke	31.00	27.50	0.99	3.09	IE*
LPG	47.31	17.20	0.99	2.95	0.05
Waste oil	20.06	23.92	0.99	1.74	NE
Electrodes (residue)	31.35	31.42	0.98	3.54	1.55
Steam Coal	27.59	25.80	0.98	2.56	0.9

* sulphur emissions from use of petroleum coke occur in the cement industry. Emission estimates for SO_2 for the cement industry are based on measurements

SO_2 emissions are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from Table 1-16 and 1-17 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Where EFs were not available the default EF from Tables 1-7 to 1-11 in the Reference Manual was used.

Recalculations

Most of the calculation sheets were revised during this inventory cycle to facilitate quality procedures. Some minor errors in the calculations were discovered during this work, regarding gases other than greenhouse gases.

3.3.2 Manufacturing industries, mobile combustion

Activity data for mobile combustion in the construction sector is provided by the NEA. Oil, which is reported to fall under vehicle usage, is in some instances actually used for machinery and vice versa. This is, however, very minimal and the deviation is believed to level out. Emissions are calculated by multiplying energy use with a pollutant specific emission factor.

The CO_2 emission factors used reflect the average carbon content of fossil fuels. Emission factors for other pollutants are taken from Table 1-49 in the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. EF for CO_2 and N_2O are presented in Table 3.7.

Table 3.7 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]	CH_4 EF [t CH_4/kt fuel]	N_2O EF [t N_2O/kt fuel]
Gas / Diesel Oil	43.33	20.20	0.99	3.18	0.7	1.3

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from construction is 11%.

3.4 Transport (1A3)

Emissions from transport accounted for 47% of the sector's total and 20% of the total GHG emissions in Iceland in 2008. Road transport accounts for 92% of the emissions in the transport sector.

3.4.1 Civil Aviation

Emissions are calculated by using Tier 1 methodology, thus multiplying energy use with a pollutant specific emission factor. Total use of jet kerosene and gasoline is based on the NEA's annual sales statistics for fossil fuels.

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 3.8. Emissions of SO_2 are calculated from S-content in the fuels.

Table 3.8 Emission factors for CO_2 and other pollutants for aviation

	NCV [TJ/kt]	C EF [t C/TJ]	Fraction oxidised	EF CO_2 [t CO_2/t]	NO_x [kg/TJ]	CH_4 [kg/TJ]	NMVOC [kg/TJ]	CO [kg/TJ]	N_2O [kg/TJ]
Jet kerosene	44.59	19.50	0.99	3.16	300	0.5	50	100	2
Gasoline	44.80	18.90	0.99	3.07	300	0.5	50	100	2

3.4.2 Road vehicles

Emissions from road traffic are estimated by multiplying the fuel use by type of fuel and vehicle, and fuel and vehicle pollutant specific emission factors. Total use of diesel oil and gasoline are based on the NEA's annual sales statistics for fossil fuels. The NEA estimates how the fuel consumption is divided between different vehicles groups, i.e. passenger cars, light duty vehicles and heavy duty vehicles. The number of vehicles in each group comes from the Road Traffic Directorate.

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

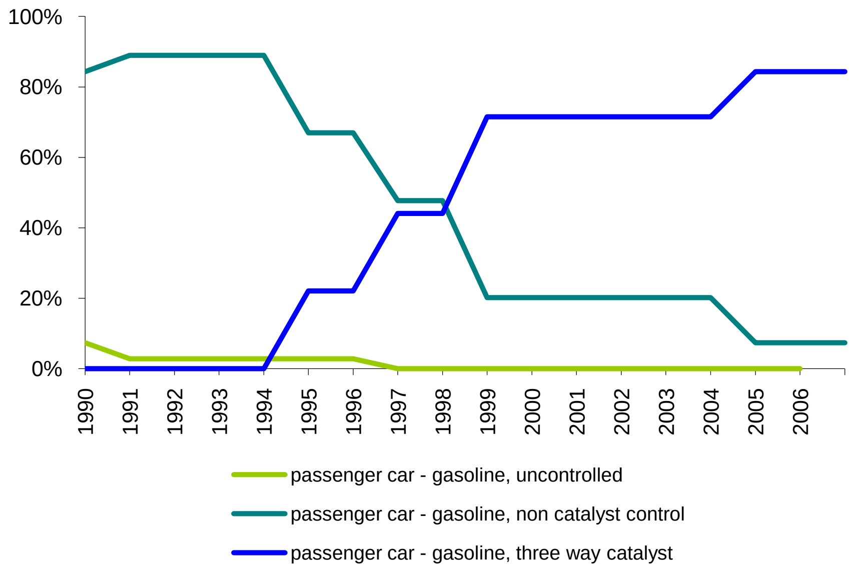

Figure 3.1. Passenger cars by emission control technology

Emission factors for CO_2, 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 3.9.

Table 3.9 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	3180
Passenger car – gasoline, non catalyst control	1.1	0.08	3180
Passenger car – gasoline, three way catalyst	0.3	0.8	3180
Light duty vehicle – gasoline	0.8	0.06	3180
Heavy duty vehicle – gasoline	0.7	0.04	3180
Passenger car – diesel	0.08	0.2	3140
Light duty vehicle – diesel	0.06	0.2	3140
Heavy duty vehicle – diesel	0.2	0.1	3140

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from road vehicles is 11%. For N_2O, both activity data and emission factors are highly uncertain. The uncertainty of N_2O emissions from road vehicles is 206%.

Recalculations

Iceland has changed the CO_2 emission factors for both gasoline and diesel oil, following a recommendation by an ERT. The default values as presented in the 1996

Guidelines are now used. This has led to the differences in emission estimates that are presented in Table 3.10.

Table 3.10 Recalculation results for road transport. Gg.

	1990	1995	2000	2005	2006	2007
Road transport (submission 2009)	517	548	620	786	901	934
Road transport (submission 2010)	529	561	633	800	914	946

3.4.3 National navigation

Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Total use of residual fuel oil and gas/diesel oil for national navigation is based on NEA's annual sales statistics for fossil fuels. 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 3.11.

Table 3.11 Emission factors for CO_2, CH_4 and N_2O for ocean-going ships

	NCV [TJ/kt]	C EF [t C/TJ]	Fraction oxidised	EF CO_2 [t CO_2/t]	EF N_2O [kg N_2O/TJ]	N_2O EF [kg N_2O/t]	EF CH_4 [kg CH_4/TJ]	EF CH_4 [kg CH_4/t]
Gas / Diesel Oil	43.33	20.20	0.99	3.18	2	0.086	7	0.30
Residual fuel oil	40.19	21.10	0.99	3.08	2	0.084	7	0.28

3.5 International bunker fuels

Emissions from international aviation and marine bunker fuels are excluded from national totals as is outlined in the IPCC Guidelines.

Emissions are calculated by multiplying energy use with pollutant specific emission factors. Activity data is provided by the NEA, which collects data on fuel sales by sector. These data distinguish between national and international usage. In Iceland there is one main airport for international flights, Keflavik Airport. Under normal circumstances almost all international flights depart and arrive from Keflavik Airport, except flights to Greenland, Faroe Islands and some flights with private airplanes which depart/arrive from Reykjavík airport. Domestic flights sometimes depart from Keflavik airport in case of special weather conditions. Oil products sold to Keflavik airport are reported as international usage. The deviations between national and international usage are believed to level out. The retail supplier divides fuel use between international navigation (including foreign fishing vessels) and national navigation. 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 3.11 above. Emission factors for aviation bunkers are also taken from the IPCC Guidelines and presented in Table 3.8 above.

3.6 Other sectors (1A4)

Sector 1A4 consists of fuel use for commercial, institutional and residential heating as well as fuel use in agriculture, forestry and fishing. Since Iceland relies largely on its renewable energy sources, fuel use for residential, commercial and institutional heating is low. Residential heating with electricity is subsidized and occurs in areas far from public heat plants. Commercial fuel combustion includes the heating of swimming pools, but only a few swimming pools in the country are heated with oil. Emissions from the fishing sector are high, since the fishing fleet is large. Emissions from fuel use in agriculture and forestry are included elsewhere; mainly in the construction sector. Emissions from the Other sector accounted for 29% of the Energy sector's total and for 13% of total GHG emissions in Iceland 2008. Fishing accounted for 95% of the Other sector's total.

3.6.1 Commercial, institutional and residential fuel combustion

This emissions from this sector are calculated by multiplying energy use with a pollutant specific emission factor. Activity data is provided by the NEA, which collects data on fuel sales by sector. The CO_2 emission factors (EF) used reflect the average carbon content of fossil fuels. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and the Good Practice Guidance. They are presented in Table 3.6 along with sulphur content of the fuels. Emissions of SO_2 are calculated from the S-content of the fuels. Emission factors for other pollutants are taken from Table 1-18 and 1-19 of the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Default EFs from Tables 1-7 to 1-11 in the Reference Manual were used in cases where EFs were not available. Emissions from waste incineration with recovery, where the energy is used for snow melting or swimming pools are reported here. A description of the method for calculating GHG is provided in Chapter 8.

3.6.2 Agriculture, forestry and fishing

Emissions from fuel use in agriculture and forestry are included elsewhere, mainly within the construction sector; thus, emissions here only stem from the fishing fleet. Emissions from fishing are calculated by multiplying energy use with a pollutant specific emission factor. Total use of residual fuel oil and gas/diesel oil for the fishing is based on the NEA's annual sales statistics for fossil fuels. 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 3.11 above.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from fishing is 7%.

3.7 Cross-cutting issues

3.7.1 Sectoral versus reference approach

Formal agreement has been made between the EA and the National Energy Authority to cover the responsibilities of NEA in relation to the inventory process. According to the formal agreement the NEA is to provide an energy balance very year, but has not yet fulfilled this provision. EA has therefore compiled data on import and export of fuels, made comparison with sales statistics and assumptions regarding stock change. Exact information on stock change does not exist. This has been used to prepare the reference approach. It is urgent to make a new agreement with NEA to further clarify the role of NEA in the inventory process and to obtain better data to use for the reference approach.

3.7.2 Feedstock and non-energy use of fuels

Emissions from the use of feedstock are according to the Good Practice Guidance accounted for in the industrial processes sector in the Icelandic inventory. This includes all use of coking coal, coke-oven coke and electrodes, except residues of electrodes combusted in the cement industry.

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.

3.8 Geothermal energy (1B2)

3.8.1 Overview

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (24.5% of the total electricity production in 2008). Geothermal energy is generally considered to have relatively low environmental impact. Emissions of CO_2 are commonly considered to be among the negative environmental effects of geothermal power production, even though they have been shown to be considerably less extensive than from fossil fuel power plants.

The key source analysis performed for 2008 has revealed that geothermal energy is a key source in terms of both level and trend, as indicated in Table 1.1.

3.8.2 Methodology

Geothermal systems can be considered as geochemical reservoirs of CO_2. Degassing of mantle-derived magma is the sole source of CO_2 in these systems in Iceland. CO_2 sinks include calcite precipitation, CO_2 discharge to the atmosphere and release of CO_2 to enveloping groundwater systems. The CO_2 concentration in the geothermal steam is site and time-specific, and can vary greatly between areas and the wells within an area as well as by the time of extraction.

The total emissions estimate is based on direct measurements. The enthalpy and flow of each well are measured and the CO_2 concentration of the steam fraction determined at the wellhead pressure. The steam fraction of the fluid and its CO_2 concentration at the wellhead pressure and the geothermal plant inlet pressure are calculated for each well. Information about the period each well discharged in each year is then used to calculate the annual CO_2 discharge from each well and finally the total CO_2 is determined by adding up the CO_2 discharge from individual wells.

Table 3.12 shows the electricity production with geothermal energy and the total CO_2 and sulphur emissions (calculated as SO_2). Large quantities of sulphur are emitted from geothermal power plants in the form of hydrogen sulfide (H_2S).

Table 3.12 Electricity production and emissions from geothermal energy in Iceland

	1990	1995	2000	2005	2006	2007	2008
Electricity production (GWh)	283	288	1323	1658	2631	3579	4037
Carbon dioxide emissions (Gg)	67	82	163	123	156	152	185
Sulphur emissions (as SO_2, Gg)	12	11	26	32	35	48	58

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from geothermal energy is 10%.

4 INDUSTRIAL PROCESSES

4.1 Overview

The production of raw materials is the main source of industrial process-related emissions for CO_2, N_2O and PFCs. Emissions also occur as a result of the use of HFCs as substitutes for ozone depleting substances and SF_6 from electrical equipments. The industrial process sector accounted for 41% of the GHG emissions in Iceland in 2008. By 2008, emissions from the industrial processes sector were 131% above the 1990 level. This is mainly due to the expansion of energy intensive industry. The dominant category within the industrial process sector is metal production, which accounted for 93% of the sector's emissions in 2008. Figure 4.1 shows the location of major industrial plants in Iceland. Some recalculation were made in the sector for this submission; PFC emissions in 2007 were corrected, minor changes were made in the estimation of emissions from mineral wool production and better data was obtained for destruction of HFCs.

Decision 14/CP.7 on the "Impact of single project on emissions in the commitment period" allows Iceland to report certain industrial process' carbon dioxide emissions separately and not include them in national totals; to the extent they would cause Iceland to exceed its assigned amount. Four projects fulfilled the provisions of Decision 14/CP.7 in 2008. Total CO_2 emissions from these projects amounted to 1163 Gg and total emissions savings from the projects are 9439 Gg.

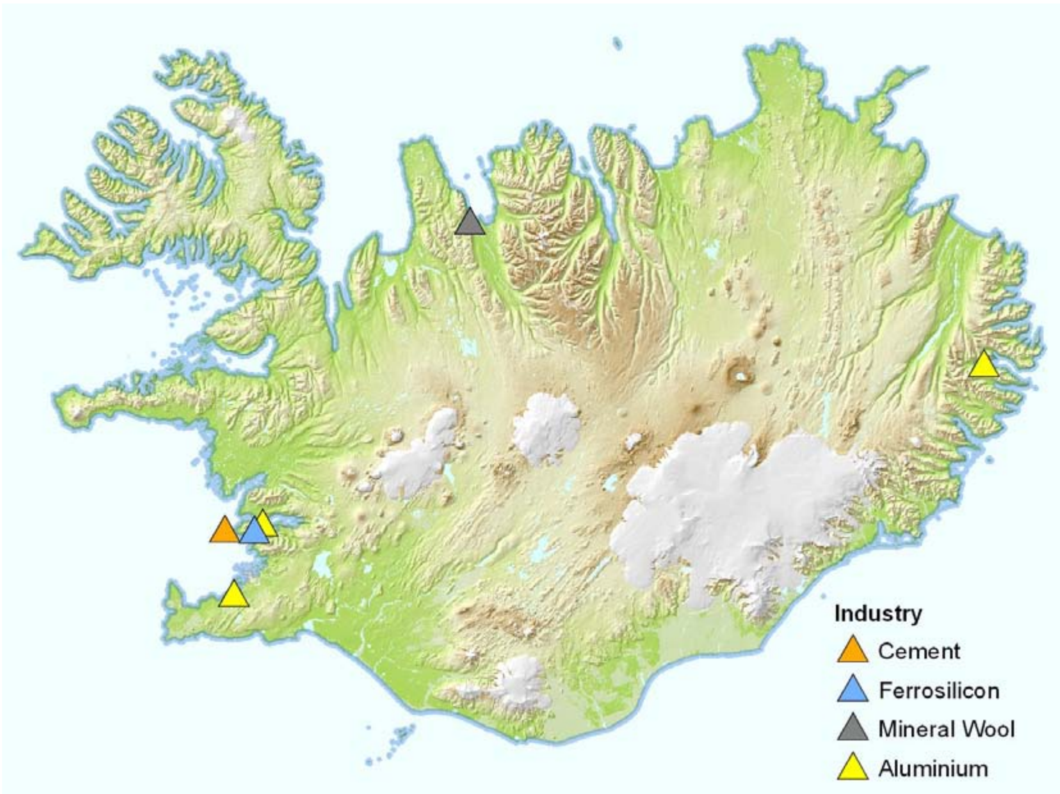

Figure 4.1 Location of major industrial sites in Iceland

4.1.1 **Methodology**

Greenhouse gas emissions from industrial processes are calculated according to methodologies suggested by the IPCC Guidelines and the Good Practice Guidance. The key source analysis performed for 2008 has revealed, as indicated in Table 1.1 and in terms of total level and/or trend uncertainty the key sources, that in the Industrial Processes Sector are the following:

- Emissions from Mineral industry – CO_2 (2A)
- Emissions from Chemical industry – N_2O (2B)
- Emissions from Ferroalloys – CO_2 (2C2)
- Emissions from Aluminium Production – CO_2 and PFCs (2C3)
- Emissions from Substitutes for Ozone Depleting Substances – HFCs (2F)

4.1.2 **Completeness**

Table 4.1 gives an overview of the IPCC source categories included in this Chapter and presents the status of emission estimates from all subcategories in the industry sector.

Table 4.1 Industrial Processes – Completeness (E: estimated, NE: not estimated, NA: not applicable, IE: included elsewhere)

	Greenhouse gases						Other gases			
Sector	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NOx	CO	NMVOC	SO_2
Mineral Products:										
Cement Production	E	NE	NE	NA	NA	NA	NE	NE	NE	IE**
Lime Production	NOT OCCURRING									
Limestone and Dolomite Use	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soda Ash Production and Use	NOT OCCURRING									
Asphalt Roofing	NOT OCCURRING									
Road Paving with Asphalt	NE	NE	NE	NA	NA	NA	E	E	E	E
Other (Mineral Wool Production)	E	NE	NE	NA	NA	NA	NE	E	NE	E
Chemical Industry										
Ammonia Production	NOT OCCURRING									
Nitric Acid Production	NOT OCCURRING									
Adipic Acid Production	NOT OCCURRING									
Carbide Production	NOT OCCURRING									
Other (Silicium Production – until 2004)*	E	NE	NE	NA	NA	NA	E	NE	NE	NE
Other (Fertilizer Production – until 2001)*	NA	NE	E	NA	NA	NA	E	NE	NE	NE
Metal Production										
Iron and Steel Production	NOT OCCURRING									
Ferroalloys Production	E	E	NA	NA	NA	NA	E	E	E	E
Aluminium Production	E	NE	NE	NA	E	NA	NE	NE	NE	E
SF_6 used in aluminium/magnesium foundries	NOT OCCURRING									
Other	NOT OCCURRING									
Other Production										
Pulp and Paper	NOT OCCURRING									
Food and Drink	NE	NA	NA	NA	NA	NA	NA	NA	NE	NA
Production of HFCs and SF_6	NOT OCCURRING									
Consumption of HFCs and SF_6	NA	NA	NA	E	NO	E	NA	NA	NA	NA
Other	NOT OCCURRING									

*Fertilizer production was terminated in 2001 and Silicium production was terminated in 2004

** SO2 emissions from cement production are reported under the energy sector, based on measurements

4.1.3 **Source specific QA/QC procedures**

The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, estimating uncertainties, archiving information and reporting. Activity data from all major industry plants is collected through electronic surveys, allowing immediate QC checks. QC tests involve automatic t/t checks on certain emissions and activity data from this industry. Further information can be found in the QA/QC manual.

4.2 Mineral Products

4.2.1 Cement Production (2A1)

The single operating cement plant in Iceland produces cement from shell sand and rhyolite in a rotary kiln using a wet process. Emissions of CO_2 originate from the calcination of the raw materiall, calcium carbonate, which comes 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 the Tier 2 method based on clinker production data and data on the CaO content of the clinker. Cement Kiln Dust (CKD) is non-calcined to fully calcined dust produced in the kiln. CKD may be partly or completely recycled in 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.

$$CO_2 \text{ Emissions} = M_{cl} \bullet EF_{cl} \bullet CF_{ckd}$$

Where,

M_{cl} is clinker production

EF_{cl} is the clinker emission factor; $EF_{cl} = 0.785 \bullet$ CaO content

CF_{ckd} is a correction factor for non-recycled cement kiln dust.

Activity data

Process-specific data on clinker production, the CaO content of the clinker and the amount of non-recycled CKD are collected by the EA directly from the cement production plant. Data on clinker production is only available for 2003-2008. Historical clinker production data has been calculated as 85% of cement production, which was the average proportion for 2003- 2005.

Table 4.2 Clinker production and CO_2 emissions from cement production from 1990 – 2008.

Year	Cement production [t]	Clinker production [t]	CaO content of clinker	EF	CKD	CO_2 emissions [kt]
1990	114,100	96,985	63%	0.495	107.5%	51.6
1991	106,174	90,248	63%	0.495	107.5%	48.0
1992	99,800	84,830	63%	0.495	107.5%	45.1
1993	86,419	73,456	63%	0.495	107.5%	39.1
1994	80,856	68,728	63%	0.495	107.5%	36.5
1995	81,514	69,287	63%	0.495	107.5%	36.8
1996	90,325	76,776	63%	0.495	107.5%	40.8
1997	100,625	85,531	63%	0.495	107.5%	45.5
1998	117,684	100,031	63%	0.495	107.5%	53.2
1999	133,647	113,600	63%	0.495	107.5%	60.4
2000	142,604	121,213	63%	0.495	107.5%	64.4
2001	127,660	108,511	63%	0.495	107.5%	57.7
2002	84,684	71,981	63%	0.495	107.5%	38.3
2003	75,314	60,403	63%	0.495	107.5%	32.1
2004	104,829	93,655	63%	0.495	107.5%	49.8
2005	126,123	99,170	63%	0.495	110%	53.9
2006	147,874	112,219	63%	0.495	110%	61.0
2007	148,348	114,668	63.8%	0.501	110%	63.2
2008	126,070	110,240	63.9%	0.502	110%	60.8

Emission factors

It has been estimated by the cement production plant that the CaO content of the clinker is 63% for all years from 1990 to 2006, 63.8% in 2007 and 63.9% in 2008. The corrected emission factor for CO_2 is thus 0.495 from 1990-2006, 0.501 in 2007 and 0.502 in 2008. The correction factor for cement kiln dust (CKD) it is 107.5% for all years except 2005 - 2008 when it is 110%.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from cement production is 8.2%.

Recalculations

Activity data for clinker production in 2002 was corrected. This resulted in lower CO_2 emissions that year, from 39.4 to 38.3 Gg.

4.2.2 Road Paving with Asphalt (2A6)

Asphalt road surfaces are composed of compacted aggregate and asphalt binder. Gases are emitted from the asphalt plant itself, the road surfacing operations and subsequently from the road surface. Information on the amount of asphalt produced comes from Statistics Iceland. The emission factors for SO_2, NO_x, CO and NMVOC are taken from Table 2-4, IPCC Guidelines Reference Manual.

4.2.3 **Mineral Wool Production (2A7)**

Emissions of CO_2 and SO_2 are calculated from the amount of shell sand and electrodes used in the production process. Emissions of CO are based on measurements that were made in year 2000 at the single plant in operation. Minor recalculations were done for mineral wool production. It was assumed earlier that the $CaCO_3$ content of the shell sand is 100%. An expert estimate is that the $CaCO_3$ content in the shell sand is 91%, which is used in the CO_2 calculations in this submission. This results in lower emissions corresponding to about 0.1 Gg for all years.

4.3 **Chemical Industry (2B5)**

The only chemical industries that have existed in Iceland involve the production of silicium and fertilizer. The fertilizer production plant was closed in 2001 and the silicium production plant was closed in 2004.

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

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

4.4 **Metal Production**

4.4.1 **Ferroalloys (2C2)**

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

Emission factors

Standard emission factors are used for CO_2, based on the carbon content of the reducing agents and electrodes. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 4.3. Values for NCV are from the Good Practice Guidance. Emission factors for CH_4, NO_x and NMVOC are taken from Tables 1-7, 1-9 and 1-11 in the IPCC Guidelines Reference Manual. Emissions of SO_2 are calculated from the sulphur content of the reducing agents and electrodes. The emission factor for CO comes from Table 2-16 in the IPCC Guidelines Reference Manual.

Table 4.3 Emission factors for CO_2 from production of ferroalloys

Carbon input	NCV [TJ/kt]	Carbon EF [t C/TJ]	Fraction oxidised	CO_2 EF [t CO_2/t input]
Coking Coal	29.01	25.80	0.98	2.69
Coke Oven Coke	26.65	29.50	0.98	2.82
Electrodes	28.00	32.14	0.98	3.23

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from ferroalloys production is 11%.

QA/QC procedures

Activity data is collected through electronic reporting form, allowing immediate QC checks. QC tests involve automatic t/t checks on certain emissions and activity data from this industry. Further information can be found in the QA/QC manual.

4.4.2 **Aluminium Production (2C3)**

Aluminium is produced in 3 smelters in Iceland, Rio Tinto Alcan at Straumsvík, Century Aluminium at Grundartangi and Alcoa Fjarðaál at Reyðarfjörður (Figure 4.1). They all use the Centre Worked Prebaked Technology. Primary aluminium production results in emissions of CO_2 and PFCs. The emissions of CO_2 originate from the consumption of electrodes during the electrolysis process. Emissions are calculated according to the Tier 1 method based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines.

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 vary 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 using the following formula:

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

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

Activity data

The EA collects annual process specific data from the aluminium plants, through electronic reporting forms.

Emission factors

The standard emission factors used for CO_2 are based on carbon content of the electrodes. They are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 4.4. The default coefficients for the calculation of PFC emissions come from the IPCC Good Practice Guidance for Centre Worked Prebaked Technology (0.14 for CF_4 and 0.018 for C_2F_6). For high performing facilities that emit very small amounts of PFCs, the Tier 3 method will likely not provide a significant improvement in the overall facility GHG inventory in comparison with the Tier 2 Method. Consequently, it is *good practice* to identify these facilities prior to selecting methods in the interest of prioritising resources. The status of a facility as a high performing facility should be assessed annually because economic factors, such as the restarts of production lines after a period of inactivity, or, process factors, such as periods of power curtailments might cause temporary increases in anode effect frequency. In addition, over time, facilities that might not at first meet the requirements for high performers may become high performing facilities through implementation of new technology or improved work practices.

Table 4.4 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

Table 4.5 Aluminium production, AE, CO_2 and PFC emissions from 1990 – 2008.

Year	Aluminium production [kt]	CO_2 emissions [Gg]	AE Anode Effect [min/cell day]	PFC emissions [Gg CO_2-eq]	CO_2 [t/t Al]	PFC [t CO_2-eq/t Al]
1990	87.839	136.5	4.44	419.6	1.55	4.78
1991	89.217	139.3	3.63	348.3	1.56	3.90
1992	90.045	134.2	1.60	155.3	1.49	1.72
1993	94.152	139.0	0.74	74.9	1.48	0.80
1994	98.595	148.0	0.42	44.6	1.50	0.45
1995	100.198	150.7	0.55	58.84	1.50	0.59
1996	103.362	157.0	0.23	25.2	1.52	0.24
1997	123.562	188.9	0.62	82.4	1.53	0.67
1998	173.869	265.5	1.18	180.1	1.53	1.04
1999	222.014	347.2	0.63	173.2	1.56	0.78
2000	226.362	345.5	0.51	127.2	1.53	0.56
2001	244.148	373.9	0.35	91.7	1.53	0.38
2002	264.107	392.6	0.25	72.5	1.49	0.27
2003	266.611	401.6	0.21	59.8	1.51	0.22
2004	271.384	407.3	0.14	38.6	1.50	0.14
2005	272.488	408.7	0.08	26.1	1.50	0.10
2006	326.270	506.9	0.86	333.2	1.55	1.02
2007	455.761	679.8	0.46	281.3	1.49	0.62
2008	781.151	1167.9	0.33	349.0	1.50	0.45

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from aluminium production is 11%.

The emission factors for calculating PFC emissions have more uncertainty. The preliminary estimate of quantitative uncertainty has revealed that the uncertainty of PFC emissions from aluminium production is 9% for CF_4 and 23% for C_2F_6.

QA/QC procedures

Activity data is collected through electronic reporting forms, allowing immediate QC checks. QC tests involve automatic t/t checks on certain emissions and activity data from this industry. Further information can be found in the QA/QC manual.

4.5 INFORMATION ON DECISION 14/CP.7

Decision 14/CP.7 allows Iceland to report certain industrial process carbon dioxide emissions separately and not include them in national totals; to the extent they would cause Iceland to exceed its assigned amount. The total amount that can be reported separately under this decision is set at 1.6 million tonnes of carbon dioxide per year. Only parties where the total carbon dioxide emissions were less than 0.05 per cent of the total carbon dioxide emissions of Annex I Parties in 1990 calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 can avail themselves of this Decision. The total carbon dioxide emissions in Iceland in 1990 amounted to 2172 Gg and the total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg (FCCC/CP/1997/7/Add.1). Iceland's CO_2 emissions were thus less than 0.016 per cent of the total carbon dioxide emissions of Annex I Parties in 1990 which is less than 0.05 per cent. Iceland availed itself of the provisions of Decision 14/CP.7 with a letter to COP, dated October 17th 2002.

In the decision a single project is defined as an industrial process facility at a single site that has come into operation since 1990 or an expansion of an industrial process facility at a single site in operation in 1990.

For the first commitment period, industrial process carbon dioxide emissions from a single project which adds in any one year of that period more than 5 per cent to the total carbon dioxide emissions in 1990 shall be reported separately and shall not be included in national totals to the extent that it would cause Iceland to exceed its assigned amount, provided that:

- Renewable energy is used, resulting in a reduction in greenhouse gas emissions per unit of production (Article 2(b));
- Best environmental practice is followed and best available technology is used to minimize process emissions (Article 2(c));

For projects that meet the requirements specified above, 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 are to be reported in the annual inventory submissions.

As mentioned above the total carbon dioxide emissions in Iceland in 1990 amounted to 2172 Gg. Industrial process carbon dioxide emissions from a single project which adds in any one year of the first commitment period more than 5 per cent to the total carbon dioxide emissions in 1990, i.e. 108.6 Gg, shall be reported separately and shall not be included in national totals to the extent that it would cause Iceland to exceed its assigned amount.

Four projects fulfilled the provisions of Decision 14/CP.7 in 2008, all three aluminium plants (Alcan, Alcoa, Century Aluminium) and the ferrosilicon plant (Elkem). The total CO_2 emissions from these projects amounted to 1163 Gg and total emissions savings from the projects are 9439 Gg. Table 4.6 provides summary information for these projects.

Table 4.6 Information on project falling under decision 14/CP.7

	Project CO_2 [Gg]	Project CO_2 % CO_2'90	Total PFC [Gg CO_2eq]	Project IEF CO_2 t/t	Total IEF PFC t CO_2eq/t	Project Electricity [GWh]	Emission savings [Gg CO_2-eq]
Alcan	131.3	6.1	4.4	1.47	0.02	2,92	1279
Alcoa	490.6	22.7	200.7	1.53	0.63	4,30	4043
Century Aluminium	401.7	18.6	143.9	1.47	0.53	4,04	3802
Elkem	139.7	6.5	NA	3.52	NA	0,19	315
Total	**1163.3**	**-**	**349.0**	**-**	**-**	**11,45**	**9439**

Practically all electricity in Iceland is produced with renewable energy sources, hydropower and geothermal (See Chapter 3 – Energy). Electricity, produced with fuel combustion is only 0.016% of the electricity production. All electricity used in heavy industry is produced from renewable energy sources. Average GHG emissions from electricity production in Iceland were 13.2 g/kWh.

For calculation of the resulting emission savings by using renewable energy, a comparison is made with a coal fired power plant. According to the International Aluminium Institute[2] the major part of the electrical power used in primary aluminium production in 2008, excluding hydropower and nuclear energy, is coal. It can therefore be assumed that if the aluminium would not be produced in Iceland using renewable energy, it would be produced with coal energy.

As explained in chapter 1.2.2, the Icelandic legislature, Althing, passed a new act on emission of greenhouse gases (No. 65/2007). According to the Act, a three-member Emissions Allowance Allocation Committee was established with representatives of the Ministry of Industry, Ministry for the Environment and the Ministry of Finance. The role of the committee is to publish a plan on how Icelandic Emission Allowances are to be allocated and distributed to the industry in the first Commitment Period, and how they are divided between general allowances according to the Kyoto Protocol (AAUs) and the special emission allowances according to Decision 14/CP.7.

The Allowance Allocation Committee has allocated emissions allowances to four production plants, operating in 2008, based on Decision 14/CP.7. Those are:

1. the expansion of the Rio Tinto Alcan Aluminium plant at Straumsvík,
2. the expansion of the Elkem Iceland Ferrosilicon plant at Grundartangi,
3. the establishment of the Century Aluminium plant at Grundartangi, and
4. the establishment of the Alcoa Fjarðaál Aluminium plant at Reyðarfjörður.

In the next section the following information for each of the projects, fulfilling the provisions of the decision will be listed:

1. Definition of the single project, according to the Allowance Allocation Committee.

[2] http://stats.world-aluminium.org/iai/stats_new/formServer.asp?form=7

2. How the projects adds more than 5% to the total carbon dioxide emission in 1990, i.e. more than 108.6 Gg
3. How renewable energy is used, resulting in reduction in greenhouse gas emissions per unit of production and the resulting emission savings
4. How BEP and BAT is used to minimize process emissions
5. Total process emissions and emission factors

Expansion of the Rio Tinto Alcan Aluminium plant at Straumsvík

1. Aluminium production started at the Aluminium plant in Straumsvík in 1969. The plant consisted in the beginning of one potline with 120 pots which was expanded to 160 pots in 1970. In 1972 a second potline, with 120 pots, was taken into operation. The second potline was expanded in 1980 to 160 pots. In 1996 a further expansion of the plant took place. The 1996 expansion project involves an expansion in the plant capacity by building a new potline with increased current in the electrolytic pots. At the same time current was also increased in potlines one and two. This has led to increased production in potlines one and two. The process used in all potlines is point feed prebake (PFPB) with automatic multiple point feed. The 1996 expansion is a single project as defined in Decision 14/CP.7.

2. In 2008 187,397 tonnes of aluminium were produced compared to 100,198 tonnes in 1995. In 2008 the production increase resulting from this project amounted to 87,199 tonnes of aluminium (69,387 tonnes in potline 3 and 17,812 tonnes in potlines 1 and 2). The resulting emissions from the production of 87,199 tonnes of aluminium are 131 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990. In 2008 118,010 tonnes of aluminium were produced in potlines 1 and 2 leading to emissions of 170 Gg of CO_2. In potline 3 69,387 tonnes of aluminium were produced, leading to emissions of 106 Gg of CO_2.

3. In 2008 the plant used 2,922 GWh of electricity, thereof 1,360 GWh were used for producing the 87,199 tonnes that fall under the definition of a single project. As stated before all the electricity used is produced from renewable sources. Average emission from producing this electricity is 13.2 g CO_2/kWh. Total CO_2 emissions from the electricity used for the project amounts to 18 Gg. Typical emissions from a coal powered power plant amount to 954 g CO_2/kWh[3]. The emissions from electricity use in the project would therefore have equalled 1297 Gg had the energy been from coal and not from renewable sources. The resulting emissions savings are 1279 Gg.

[3] http://tonto.eia.doe.gov/ftproot/environment/co2emiss00.pdf

4. Best available techniques, as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, are applied in the production of aluminium to minimize process emissions:
    a. All pots are closed and the pot gases are collected and cleaned via a dry absorption unit; the technique is defined as BAT.
    b. Prebake anodes are used and automatic multiple point feed.
    c. Computer control is used in the potlines to minimize energy use and formation of PFC.

    BEP is used in the process and the facility has a certified environmental management system according to ISO 14001. The environmental management system was certified in 1997. Besides the environmental management system, the facility also has a certified ISO 9001 quality management system and an OHSAS 18001 occupational health and safety management system .

5. Total process emissions from production of 187,397 tonnes of aluminium at Rio Tinto Alcan were 280 Gg CO_2 equivalents in 2008, 276 Gg of CO_2 from electrodes consumption and 4.4 Gg CO_2-eq of PFCs due to anode effect. Besides that 12.4 Gg were emitted from fuel combustion. The resulting IEF are 1.47 tonnes CO_2 per tonne of aluminium and 0.02 tonnes of PFC in CO_2 equivalents per tonne of aluminium. For comparison, the median value of PFC emissions in 2006 for prebake plants worldwide was 0.24 CO_2 equivalents per tonne of aluminium[4]. The IEF for fuel use is 0.07 t CO_2 eq per tonne of aluminium.

Expansion of the Ferrosilicon plant at Grundartangi

1. The Elkem Iceland Ferrosilicon plant at Grundartangi was established in 1977, when the construction of two furnaces started. The first furnace came on stream in 1979 and the second furnace a year later. The production capacity of the two furnaces was in the beginning 60,000 tonnes of ferrosilicon, but was later increased to 72,000 tonnes. In 1993 a project was started that enabled overloading of the furnaces in comparison to design, resulting in increased production. The production was further increased in 1999 by the addition of a third furnace. The production increase since 1990 is a single project as defined in Decision 14/CP.7. In the production raw ore, carbon material and slag forming materials are mixed and heated to high temperatures for reduction and smelting. The carbon materials used are coal, coke and wood. Electric (submerged) arc furnaces with Soederberg electrodes are used. All furnaces are semi-covered. Furnace 3 can not use wood in the process.

[4] International Aluminum Institute

2. In 1990 62,792 tonnes were produced leading to emissions of 204 Gg of CO_2. In 2008 96,407 tonnes were produced (22,975 tonnes in furnace 1; 33,790 tonnes in furnace 2; and 39,642 tonnes in furnace 3) leading to emissions of 339 Gg of CO_2. The production falling under Decision 14/CP.7 is thus 39,642 tonnes of ferrosilicon (all production in furnace 3; the production increase since 1990 is less than the production in furnace 3 due to reconstruction of furnace 1 in 2008). This production lead to emissions of 140 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990. In 2008 22,975 tonnes were produced in furnace 1 leading to emissions of 80 Gg of CO_2; 33,790 tonnes were produced in furnace 2 leading to emissions of 119 Gg of CO_2 and 39,642 tonnes were produced in furnace 3 leading to emissions of 140 Gg of CO_2.

3. In 2008 the plant used 815 GWh of electricity, thereof 335 GWh were used for the production increase since 1990 (39,642 tonnes of ferrosilicon). All the electricity used for the production comes from renewable sources. The average CO_2 emissions from producing this electricity are 13.2 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 4 Gg. Had the energy been from a coal powered power plant the emissions would amount to 954 g/kWh. The resulting emissions from electricity use in the project would in this case have amounted to 320 Gg CO_2. Emissions savings from using renewable energy for the project are 315 Gg CO_2.

4. The plant uses BAT according to the IPPC Reference Document on Best Available Technology in non ferrous metals industries (December 2001), and further the plant has an environmental management plan as a part of a certified ISO 9001 quality management system, meeting the requirement of BEP.

5. Total process emissions from production of 96,407 tonnes of ferrosilicon at Elkem Iceland in 2008 were 339 Gg CO_2 equivalents. The resulting IEF are 3.52 tonnes CO_2 per tonne of ferrosilicon. Besides that 0.8 Gg CO_2 were emitted from fuel combustion. The IEF for fuel use is 0.008 t CO_2 equivalents per tonne of ferrosilicon.

Establishment of the Century Aluminium plant at Grundartangi

1. The Century Aluminium plant at Grundartangi was established in 1998. The plant consisted in the beginning of one potline. In 2001 a second potline was taken into operation. In 2006 a further expansion of the plant took place. The Century Aluminium plant is a single project as defined in Decision 14/CP.7.

2. In 2008 the Century Aluminium plant produced 273,825 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 402 Gg.

This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2008 the plant used 4,041 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 13.2 g/kWh. The resulting total CO_2 emissions from the electricity use are 53 Gg. Had the energy been from a coal powered power plant the emissions would have amounted to approximately 954 g/kWh, resulting in emissions from electricity use in the project equivalent to 3855 Gg. Emissions savings from using renewable energy equal 3082 Gg.

4. Best available techniques, as defined by the IPPC, are applied at the Century Aluminium plant as stipulated in the operating permit. Century Aluminium has reported that they are preparing implementation of an environmental management system according to ISO 14001.

5. Total process emissions from production of 273,825 tonnes of aluminium at Century Aluminium in 2008 were 546 Gg CO_2 equivalents, 402 Gg of CO_2 from electrodes consumption and 144 Gg CO_2 equivalents of PFCs due to anode effect. Besides that 2.0 Gg were emitted from fuel combustion. The resulting IEF are 1.47 tonnes CO_2 per tonne of aluminium and 0.53 tonnes of PFC in CO_2 equivalents per tonne of aluminium. The IEF for fuel use is 0.007 t CO_2 equivalents per tonne of aluminium.

Establishment of the Alcoa Fjarðaál Aluminium plant at Reyðarfjörður

1. The Alcoa Fjarðaál Aluminium plant at Reyðarfjörður was established in 2007. In 2008 the plant reached full production capacity, 346,000 tonnes of aluminium per year. The Alcoa Aluminium plant is a single project as defined in Decision 14/CP.7.

2. In 2008 the Alcoa Aluminium plant produced 319,929 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 491 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2008 the plant used 4,297 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 13.2 g/kWh. The resulting total CO_2 emissions from the electricity use are 57 Gg. Had the energy been from coal powered power plant the emissions would amount to approximately 954 g/kWh, resulting in emissions from electricity use in the project equivalent to 4099 Gg. Emissions savings from using renewable energy equal 4043 Gg.

4. Best available techniques, as defined by the IPPC, are applied at the Alcoa Aluminium plant as stipulated in the operating permit. Alcoa Fjarðaál is preparing implementation of an environmental management system according to ISO 14001. Further, two audits have been performed in accordance with Alcoa´s Self Assessment Tool (ASAT). If the provisions of ASAT are met, all requirements of ISO 14001 should be met.

5. Total process emissions from production of 319,929 tonnes of aluminium at Alcoa Fjarðaál in 2008 were 691 Gg CO_2 equivalents, 491 Gg of CO_2 from consumption of electrodes and 201 Gg CO_2 equivalents of PFCs due to anode effect. Besides that, 2.8 Gg were emitted from fuel combustion. The resulting IEF are 1.53 tonnes CO_2 per tonne of aluminium and 0.63 tonnes of PFC in CO_2 equivalents per tonne of aluminium. The IEF for fuel use is 0.009 t CO_2 equivalents per tonne of aluminium.

4.6 Other production

Other production in Iceland is the Food and Drink Industry. Emissions from this sector have not been estimated. The emissions are mainly NMVOCs.

4.7 Production of Halocarbons and SF_6

There is no production of halocarbons and SF_6 in Iceland.

4.8 Consumption of Halocarbons and SF_6

4.8.1 Emissions of HFCs

HFCs are used as substitutes for the ozone depleting substances (CFCs and HCFCs) which are being phased out by the Montreal Protocol. In Iceland the F-gases have been regulated since 1998, and HFCs are banned for certain uses. HFCs are imported in bulk for use in stationary and mobile air-conditioning systems, and in imported equipment e.g. refrigerators, cars and metered dose inhalers. HFCs are banned in other aerosols, solvents and fire extinguishers. The HFCs used in Iceland are HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a and HFC-152a.

The bulk import of HFCs started in 1992 and increased until 1998. Annual imports stayed between 30 and 70 Gg CO_2-equivalents in following years, but an increase is seen in the years 2007 and 2008. No import of HFC 152a took place in 2008. It is assumed that the import of cars with MAC (mobile air-conditioning systems) started in 1995. Since then there has been a rapid increase in private cars with MAC, and from the year 2005 about 30-40% of all private cars have MAC, all busses and about 60% of larger trucks. The use of HFCs in some applications, specifically rigid foam (typically closed-cell foam), refrigeration and fire suppression, can lead to the development of long-lived banks of HFC. Sufficient data are available to calculate actual emissions in most applications. The total HFC import in 2008 was 111 Gg CO_2-

equivalents, emissions were 67 Gg CO_2-equivalents and HFCs stored in banks was 427 Gg CO_2-equivalents (Figure 4.2). In 2008 the actual emissions of HFCs were about 1.4% of national total greenhouse gas emissions (without LULUCF). This source category is a key source in both level and trend.

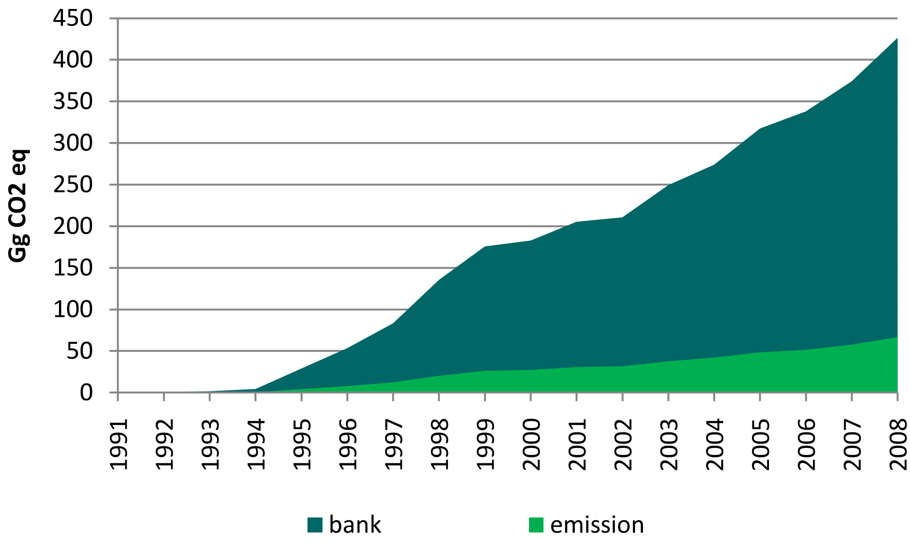

Figure 4.2 HFCs emissions and HFCs accumulated in banks

Method

Emissions of HFCs (sector 2F) are calculated using the Tier 1 methodology which takes into account the import, export and destruction of chemicals in bulk and in equipment with time lag.

Data on imported and exported bulk are reported directly to the EA each year. Data on imported cars are gathered from the Road Traffic Directorate and data on imported dose inhalers are gathered from The Icelandic Medicines Control Agency. Data on HFCs in refrigeration equipment is estimated from import statistics, based on land of origin and type of refrigerator. There is no destruction facility of HFCs in Iceland, but some amounts are exported every year for destruction. The amount exported for destruction was re estimated this year, as some sources had not been accounted for.

Activity data

Information on the import of chemicals in bulk is reported directly to the EA. The importers are required to report the type and amount of HFC they import in order to release the chemicals from the customs agency. It is assumed that 95% of HFC-134a is used in refrigeration equipment and 5% for air conditioning in vehicles. Other chemicals imported in bulk are assumed to be used in refrigeration equipment.

Estimates of HFCs emissions from cars are based on data of imported cars combined with expert estimates based on surveys performed by EA. An average lifetime of equipment is reported in Table 4.7.

Table 4.7 Average lifetime of equipment

Refrigeration systems	15 years
MAC	12 years
Dose inhalers	2 years

Uncertainty

The activity data are obtained from official data and are considered reliable. The exact number of cars with MAC systems is not available; approximation is used in accordance with the survey performed by EA. The level of proper disposal of HFCs in used refrigerators and refrigeration system and MAC systems in cars is uncertain.

Uncertainty varies between HFC types. The uncertainty is greatest for HFC-134a due to its widespread application in products that are imported and exported for destruction. Uncertainties that arise due to imperfect measurement and assessment are a significant issue for emission estimates from MAC (HFC-134a) and emissions estimates from commercial refrigerants (HFC-134a). The estimate of quantitative uncertainty has revealed that the uncertainty of HFC emissions is 55%.

Recalculation

Emissions of HFCs were revised as EA received new export data on HFC-134a for destruction from 2001 to 2007. This revision leads to a decrease of 2% – 5% in HFC emission in years concerned.

Planned improvements

Considerable progress was made towards improving estimates for this source for the 2009 submission. Still there are uncertainties; the use of HFCs in surgery as well as in foam blowing agents has not been assessed.

4.8.2 Emissions of SF_6 from Electrical Equipment

Sulphur hexafluoride (SF_6) is mainly used for insulation and current interruptions in equipment used in the transmission and distribution of electricity. To a minor extent, SF_6 is used in research particle accelerators in universities.

There is no SF_6 production in Iceland. Consumption of SF_6 is mainly through insulation in electrical distribution systems. Actual emissions of SF_6 have been estimated through questionnaires addressed to power companies asking for the installed amounts of SF_6 in operating equipment, and the replaced amounts of SF_6 during service. Data on SF_6 use dates back to 1974. The IPCC default emission factor of 6% is used for installation emissions (Table 3.2, IPCC GPG). The results showed an installed accumulated amount of approximately 18,800 kg SF_6. This is probably a slight underestimate as there might be some data missing. One of the larger power stations (Blanda) has been registering leakage since 2006. Leakage is usually negligible, but taking into account exceptional leakage an annual leakage rate of 0.8% was used as input data in this inventory. There is no data on retired equipment.

SF_6 Emission from insulation in the electrical distribution system

Total emissions of SF_6 = Installation Emissions + Use Emission + Disposal Emissions

SF_6 emission from university particle accelerators has been estimated by use of import data dating back to 1993. On average, 44 kg of SF_6 have been imported each year for these purposes. The IPCC default emission factor of 7% is used for use emissions (Table 3.2, IPCC GPG).

University and Research Particle Accelerator SF_6 Emissions

Total emissions of SF_6 = Use Emissions

Planned improvements

Considerable progress was made towards improving estimates for this source for the 2009 submission. More detailed data will be collected and this category will be moved to Tier 2 by next submission.

5 SOLVENT AND OTHER PRODUCT USE

The use of solvents and products containing solvents leads to emissions of non-methane volatile organic compounds (NMVOC), which are regarded as indirect greenhouse gases. Estimates of NMVOC emissions are based on data on imports of solvents combined with expert estimates based on surveys. Import data are obtained from Statistics Iceland. The NMVOC emissions will over a period of time oxidize to CO_2 in the atmosphere. This conversion has been estimated with the use of the following equation:

$$CO_2 \text{ emission} = 0.85 \times \text{NMVOC emissions} \times 44/12$$

where 0.85 is the carbon content of the NMVOCs.

Other emissions reported under the sector solvent and other product use are due to use of N_2O, mainly for medical purposes, and also, to a smaller extent, for car racing. Data on sold amounts are collected directly by the Environment Agency.

6 AGRICULTURE

6.1 Overview

Icelanders are self-sufficient in all major livestock products, such as meat, milk and eggs. Traditional livestock production is grassland-based and most are native breeds, i.e. dairy cattle, sheep, horses and goats, which all are of an ancient Nordic origin, one breed for each species. These animals are generally smaller than the breeds common elsewhere in Europe. Beef production, however, is partly through imported breeds, as is all pork and poultry production. There is not much arable crop production in Iceland, due to the cold climate and subsequently short growing season. Cropland in Iceland consists mainly of cultivated hayfields, but potatoes and barley are grown on limited acreage. The Agriculture sector accounted for 12% of total greenhouse gas emissions in 2008. Emissions were 2% below 1990 levels.

Recalculations were made in the sector for this submission. Enteric fermentation from cattle and sheep was moved from Tier 1 to Tier 2. Population statistics for those species were revised. Nitrogen excretion factors for swine and cattle were revised. Additionally, cultivation of organic soils is now included in the Agriculture sector.

6.1.1 Methodology

The calculation of greenhouse gas emissions from agriculture is based on the methodologies suggested by the IPCC Guidelines and the Good Practice Guidance.

As indicated in Table 1.1, the key source analysis performed for 2008 has revealed that in terms of total level and/or trend uncertainty the key sources in the agriculture sector are as follows:

- Emissions from Enteric Fermentation, Cattle – CH_4 (4A1)
- Emissions from Enteric Fermentation, Sheep – CH_4 (4A3)
- Manure management – N_2O (4B)
- Direct Emissions from Agricultural Soils – N_2O (4D1)
- Indirect Emissions from Agricultural Soils – N_2O (4D2)

6.1.2 Completeness

Table 6.1 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all sub-sources in the agricultural sector.

Table 6.1 Agriculture – completeness (E: estimated, NE: not estimated, NA: not applicable)

	Greenhouse gases		
Sector	CO_2	CH_4	N_2O
Enteric Fermentation	NA	E	NA
Manure Management	NA	E	E
Rice Cultivation	Not Occurring		
Agricultural Soils			
Direct emissions	NA	NE	E
Animal Production	NA	NE	E
Indirect emissions	NA	NE	E
Prescribed burning of Savannas	Not Occurring		
Field burning of agricultural residues	Not Occurring		
Other	Not Occurring		

6.2 Enteric Fermentation

The production of CH_4 by enteric fermentation in animals varies with digestive systems 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 significant. The methodology for calculating methane from enteric fermentation is in accordance with the Tier 2 method for cattle and sheep and Tier 1 method for other livestock. Both the population levels and emission factors by type of animal are used to calculate the emissions.

Activity data

The Farmers Association of Iceland (FAI) is, on behalf of the Icelandic Food and Veterinary Authority, in charge of recording the size of all farm animal population every year, namely the annual livestock census. These numbers are reported to Statistics Iceland that publishes them officially. On request from the EA, the FAI assisted EA in coming up with a method to account for young animals, but those are mostly excluded from national statistics on animal populations. For this submission FAI assisted EA to divide cattle and sheep into the subcategories necessary to estimate emissions with Tier 2 method. This revision led to some changes in the population of calves and lambs as mistakes in previous estimates were discovered. The population of calves was overestimated before as corrections were not made for average life span. Populations of lambs were also slightly overestimated. Table 6.2 shows animal population according to Statistics Iceland and Table 6.3 shows the corrected animal population data, with subcategories.

Table 6.2 Animal population data from Statistics Iceland

	1990	1995	2000	2005	2006	2007	2008
Cattle, total	74889	73199	72135	65979	68670	70660	72012
Dairy cattle	32246	30428	27066	24538	25504	26048	26211
Non-dairy cattle	42643	42771	45069	41441	43166	44612	45801
Sheep	548508	458341	465777	454950	455656	454812	457861
Goats	345	350	416	439	449	524	563
Horses	71693	78202	73995	74820	75644	76982	77502
Swine	3116	3726	3862	3982	4218	4147	4265
Poultry	214936	164402	178093	166119	181857	184244	168515
Mink	42000	29941	36593	35935	41957	41497	33806
Foxes	4800	7308	4132	774	116	93	5

Table 6.3 Corrected population data

	1990	1995	2000	2005	2006	2007	2008
Cattle, total	64844	66262	64729	58172	59898	62088	63575
Dairy cattle	32249	31165	28015	25893	26949	27541	27825
- high producing	32249	30428	27066	24538	25504	26048	26211
- low producing	0	737	949	1355	1445	1493	1614
Non-dairy cattle	32595	35097	36714	32279	32949	34547	35750
- other mature	22536	28160	26208	21961	22048	23741	24870
- young cattle	10059	6937	10506	10318	10901	10806	10880
Sheep, total	735520	615638	619929	595289	592443	591858	597444
- mature ewes	445635	372222	373194	360375	358531	358167	361485
- other mature	13277	12376	12091	11227	11370	11375	11583
- young sheep	276608	231040	231644	223687	222542	222316	224376
Goats	518	525	624	659	674	786	845
Horses	74961	81384	76667	77303	78722	80115	80656
Swine, total	29645	31130	32267	33269	35241	36648	35634
- swine	3135	3726	3862	2982	4218	4147	4265
- pigs	26510	27404	28405	29287	31023	30501	31369
Poultry	771585	590069	693061	596232	652718	661286	604832
Mink	42000	29941	36593	35935	41957	41497	33806
Foxes	4800	7308	4132	774	116	93	5

The large difference in swine and poultry levels between the official population data and the corrected data is due to the significant disparity between the breeding stock and the whole population including young animals. For swine, the national statistics include only the breeding stock, so all young animals have to be added. This is done by estimating the total number of pigs per sow (15 pigs/sow from 1990 to 1994 and 17 pigs/sow from 1995 onwards) and an estimated average life span of a piglet of 165 days. For poultry, the population of young animals was estimated on basis of the poultry consumption of the Icelandic nation in 2002 and the same ratio used for all years from 1990.

Emission factors

Country-specific emission factors for cattle and sheep were calculated by the AUI from feed intake according to the Tier 2 method. Emission factors for other livestock species are taken from the IPCC Guidelines, except for fur animals which were taken from Norway's NIR 2007. They are presented in Table 6.4.

Table 6.4 Emission factors for CH_4 from enteric fermentation

	kg CH_4 per head per year	Source of EF
Dairy cattle, high producing	83.87	Country specific
Dairy cattle, low producing	53.33	Country specific
Other mature cattle	37.64	Country specific
Young cattle	8.98	Country specific
Mature ewes	13.17	Country specific
Other mature sheep	9.76	Country specific
Young sheep	5.63	Country specific
Goats	5	Table 4-3, IPCC '96 GL
Horses	18	Table 4-3, IPCC '96 GL
Swine	1,5	Table 4-3, IPCC '96 GL
Fur animals	0.1	Revised NIR 2007, Norway

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CH_4 emissions from enteric fermentation is 54%.

Recalculations

Enteric fermentation from cattle and sheep was moved from Tier 1 to Tier 2. Population statistics for those species were revised. This has led to the differences in emission estimates that are presented in Table 6.5.

Table 6.5 Recalculation results for enteric fermentation. Gg CO_2 equivalents.

	1990	1995	2000	2005	2006	2007
Cattle (submission 2009)	117.7	108.0	103.3	94.3	98.1	100.7
Cattle (submission 2010)	76.5	78.0	71.4	64.0	66.0	68.4
Sheep (submission 2009)	128.9	107.7	109.4	106.9	107.0	106.8
Sheep (submission 2010)	158.7	132.8	153.1	128.5	127.8	127.7

6.3 Manure management

Manure production is responsible for methane and nitrous oxide emissions. Methane is produced during the anaerobic decomposition of manure, while nitrous oxide is produced during the storage and treatment of manure prior to it being used as fertilizer.

CH_4 emissions from Manure Management were estimated according to the IPCC Tier 1 methodology. Population levels for each kind of animal, and the relevant emission factors were used to calculate the emissions.

Emission factors are taken from the IPCC Guidelines, except for those for fur animals which are taken from Norway's NIR 2007. They are presented in Table 6.6, but are likely to be overstated, as domestic livestock breeds of cows, horses and sheep are generally smaller than in other European countries.

Table 6.6 Emission factors for CH_4 from manure management

	kg CH_4 per head per year	Source of EF
Dairy cattle	14	Table 4-6, IPCC '96 GL
Non-dairy cattle	6	Table 4-6, IPCC '96 GL
Sheep	0.19	Table 4-5, IPCC '96 GL
Goats	0.12	Table 4-5, IPCC '96 GL
Horses	1.4	Table 4-5, IPCC '96 GL
Swine	3	Table 4-6, IPCC '96 GL
Poultry	0.078	Table 4-6, IPCC '96 GL
Fur animals – minks	0.405	Revised NIR 2007, Norway
Fur animals – foxes	0.65	Revised NIR 2007, Norway

In order to calculate N_2O emissions from manure management, the default IPCC methodology was used, according to the following equation.

$$E = \sum_{S}(\sum(N_T \times Nex_T \times MS_{T,S})) \times EF_S$$

where E is N_2O emissions, T is the animal species index, S is the manure management system index, N_T is the livestock population, Nex_T is the annual average N excretion per head of species, $MS_{T,S}$ is the fraction of total annual excretion for each livestock species that is managed in system S and EF_S is the N_2O emission factor for system S.

The emission factors for N excretion are presented in Table 6.10. Emission factors for N_2O-N/N are those suggested by the IPCC Guidelines. The treatment of manure in different management systems per animal species was estimated by the Agricultural University of Iceland. There have been some changes in the manure management practices over the time series. For example the share of liquid systems for cattle is believed to have increased from 46% in 1990 to 53% in 2008. The shares of manure management systems per animal species differ therefore for the period 1990 – 2008. The situation in 1990 to 2008 is reflected in Table 6.7.

Table 6.7 Manure management systems

	1990	1995	2000	2005	2006	2007	2008
Cattle:							
- Liquid	46%	49%	53%	53%	53%	53%	53%
- Solid	20%	17%	13%	13%	13%	13%	13%
- pasture	34%	34%	34%	34%	34%	34%	34%
Sheep and goats:							
- liquid	17%	17%	17%	17%	17%	17%	17%
- solid	41%	41%	41%	41%	41%	41%	41%
- pasture	42%	42%	42%	42%	42%	42%	42%
Horses:							
- solid	17%	17%	17%	17%	17%	17%	17%
- pasture	83%	83%	83%	83%	83%	83%	83%
Swine:							
- liquid	90%	95%	100%	100%	100%	100%	100%
- solid	10%	5%	0%	0%	0%	0%	0%
Poultry:							
- solid	100%	100%	100%	100%	100%	100%	100%
Fur animals:							
- liquid	10%	10%	10%	10%	10%	10%	10%
- solid	90%	90%	90%	90%	90%	90%	90%

Recalculations

The revision of population statistics for cattle and sheep as well as the changes in Nex for cattle and swine has led to changes in emissions estimates for manure management. Those differences that are presented in Table 6.8.

Table 6.8 Recalculation results for manure management. Gg CO_2 equivalents.

	1990	1995	2000	2005	2006	2007
submission 2009	58.5	52.4	50.7	47.9	49.8	49.9
submission 2010	54.0	50.9	50.1	46.9	48.2	48.8

6.4 Emissions from Agricultural Soils – N_2O (4D)

6.4.1 Description

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

- Direct emissions from agricultural soils (applicable to Iceland for the use of synthetic fertilizers, applied animal manure, crop residue, cultivation of soils). This is a key source in both level and trend.
- Direct soil emissions from production of animals
- N_2O emissions indirectly induced by agricultural activities (N losses by volatilization, leaching and runoff). This is key source in level and trend.

6.4.2 Methodological issues

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

Use of synthetic fertilizer

Direct emissions of N_2O from the use of synthetic fertilizers are calculated from data on annual usage of fertilizers and their nitrogen content, multiplied by the IPCC default emission factor. Since the closure of the fertilizer production plant in 2001, there is no domestic production of synthetic fertilizers in Iceland and Statistics Iceland collects information on the total annual import of synthetic fertilizers. The amount of synthetic fertilizers used in the forestry and revegetation sectors is subtracted from the total imported amount to find out the amount used in agriculture. The emissions are corrected for ammonia that volatilizes during application. The IPCC default fraction of 0.1 for volatilization is used.

Table 6.9 Use of synthetic fertilizer in Iceland, tonnes.

	1990	1995	2000	2005	2006	2007	2008
Total import	12474	11197	12681	9775	12342	13832	15321
Use in forestry	3	4	16	18	19	23	18
Use in revegetation	334	303	362	812	831	534	775
Use in agriculture	**12140**	**10894**	**12319**	**8946**	**11492**	**12950**	**14528**

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 nitrogen excretion factors for each kind of animal, presented in Table 6.10. They are taken from Sveinsson, Þ. (1998), from Óskarsson and Eggertsson (1991), from Norway's NIR 2007 and from Danish statistics (Normtal for husdyrgödning, 2009). The nitrogen excretion factors have been revised for cattle and swine since last submission. As mentioned above, pork production in Iceland is through imported breeds. As the breeds are imported from Denmark, and the feeding situation is according to Danish methods, the Nex for swine are taken from Danish statistics. For cattle there have been some changes in the management practices over the time series. Therefore the Nex is believed to have grown linearly over the time series, reaching a final value in 2000. Since Nex values are not available in 1990 for subcategories of cattle, they were found by multiplying the Nex for dairy cattle with the ratio of Nex for the subcategory to Nex for high producing dairy cattle in year 2000.

The nitrogen emissions are corrected for ammonia that volatilizes during application. The IPCC default fraction of 0.2 for volatilization is used.

Table 6.10 Nitrogen excretion factors

	kg N per head per year		Source of EF	
	1990	2000	1990	2000
Dairy cattle, high producing	60.0	103.0	[1]	[2]
Dairy cattle, low producing	35.0	60	Ratio	[3]
Other mature cattle	22.1	38	Ratio	[2]
Young cattle	11.1	19	Ratio	[2]
Sheep	5.76	5.76	[1]	[1]
Goats	5.76	5.76	Assumed to be the same as for sheep	
Horses	28.8	28.8	[1]	[1]
Swine	25.8	25.8	[3]	[3]
Pigs	3.0	3.0	[3]	[3]
Poultry	0.42	0.42	[1]	[1]
Fur animals – minks	4.27	4.27	[4]	[4]
Fur animals – foxes	9.0	9.0	[4]	[4]

[1] Óskarsson and Eggertsson (1991)
[2] Sveinsson (1998)
[3] Danish statistics (2009)
[4] Revised National Inventory Report 2007, Norway

Crop residue

Cropland in Iceland consists mainly of cultivated hayfields. From the crops listed in the IPCC Guidelines only potatoes and barley are grown outdoors in Iceland. The potato production was significantly smaller in 1993 to 1995 due to an epidemic of fungal disease. The production of barley started in 1992 and has risen the last few years. Barley is almost solely used as fodder. Only a very small fraction is used for human consumption. Table 6.11 provides an overview of crop production from 1990 to 2008.

Table 6.11 Potato and barley production

	1990	1995	2000	2005	2006	2007	2008
Potatoes (tonnes)	14893	7324	9843	7250	13800	13000	12500
Barley (tonnes)	NE	485	3041	9773	11253	11246	15413

Emissions from crop residue are very small, since almost all barley is used as fodder and the crop residue is either used as animal bedding, compost or in greenhouses. Emissions of N_2O amounted to 0.2 Gg CO_2-equivalents in 2008.

Cultivation of organic soils

N_2O emissions from cultivated organic soils are now included under the Agriculture sector, as was requested by the ERT that reviewed Iceland's 2009 submission. In earlier submissions, they were not estimated separately but included under N_2O emission from drained organic Grassland soils in the LULUCF sector. The area of cultivation of organic soils, including Histosol, Histic Andosol and Hydric Andosol, is estimated to be 55,198 ha. A country specific emission factor of 0.99 kg N_2O-N per ha is used (Guðmundsson, 2009, see also Chapter 7.18.2.2).

Direct soil emission from animal production

The fraction of the total amount of animal manure produced, which is deposited on pastures during grazing, is set to be 40 - 45% and differs between years. The Agricultural University of Iceland 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 volatilization

Atmospheric deposition of nitrogen compounds fertilizes soils and surface waters, and enhances biogenic N_2O formation. Climate and the type of fertilizer influence the ammonia volatilization. The IPCC default values for volatilization are used (10% for synthetic fertilizers and 20% for animal manure).

N_2O from leaching and runoff

A considerable amount of nitrogen from fertilizers is lost from agricultural soils through leaching and runoff. Fertilizer 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 for the emissions of N_2O from animal production, which are 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.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of direct N_2O emissions from agricultural soils is 102% and the uncertainty of indirect emissions from Nitrogen used in agriculture is 102%.

Recalculations

The revision of population statistics for cattle and sheep, the changes in Nex for cattle and swine as well as the inclusion of cultivation of histosols has led to changes in emissions estimates for agricultural soils. Differences are presented in Table 6.12.

Table 6.12 Recalculation results for agricultural soils. Gg CO_2 equivalents.

	1990	1995	2000	2005	2006	2007
submission 2009	244.0	224.1	235.8	199.1	226.2	244.7
submission 2010	256.2	248.2	266.9	228.3	255.1	274.1

7 LULUCF

7.1 Overview

This chapter provides estimates of emissions and removals from Land Use, Land-Use Change and Forestry (LULUCF) and documentation of the implementation of guidelines given in “2006 Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use” (IPCC 2006) hereafter named AFOLU Guidelines. The LULUCF reporting is according to the CRF LULUCF tables. This section was written by the Agricultural University of Iceland (AUI) in close cooperation with Icelandic Forest Research (IFR) and Soil Conservation Service of Iceland (SCSI) on chapters related to forestry and revegetation.

The CRF for LULUCF was prepared through UNFCC CRF Reporter program (version 3.4.3). Land use categories have been decided and formally defined. The classification of land according to these definitions is implemented for all the main land-use categories. Structure of further subdivision of land has been defined although only implemented for some categories. There are modifications from last submission in the structure of information of three categories reported.

The modifications are;

(1) Forest land:

(a) The conversion period for land converted to forest has been changed from the default value of 20 years to 50 years (see 7.12).

(b) The subcategories of Forest land have been modified. For Forest land remaining Forest land is now divided to; “Natural birch forest”, “Afforestation older than 50 years” and “Plantations in natural birch forest” Instead of the subcategories “Natural birch forests” and Plantations older than 20 years. Land converted to Forest Land is now reported as “Afforestation 1-50 years old” instead of “Plantations 1-20 years old” and as before subdivided between two categories i.e. Grassland converted Forest Land and Other Land converted to Forest Land.

(2) Cropland:

All emissions from drained wetlands except those under Forest Land have in previous submissions been reported as aggregate number under Wetland converted to Grassland. Carbon stock changes under 5.C.2.3 Wetland converted to Grassland and N_2O under 5.G. Wetland converted to Grassland Non-CO_2 emission, 5(II). In this submission, Carbon stock changes in drained wetlands are reported under 5.B.2.3 Wetland converted to Cropland and 5.C.2.3 Wetland converted to Grassland. The N_2O emission from wetlands converted to grassland is still reported under 5.G. Wetland converted to Grassland Non-CO_2 emission - 5(II), but N_2O emission from drained Cropland is reported under 4.D.

(3) Other:

The category “Revegetation” under “Other” is renamed to “Other emissions due to Revegetation activities”.

The AUI has since 2007 been constructing the Icelandic Geographically Land use Database (IGLUD) to meet the requirements of the LULUCF reporting. In this year's submission the area estimate for the main land use categories is based on this database except where more precise estimates are available.

Time series for land conversion are provided for some categories although still incomplete. The conversion period used is variable between categories as explained below. Wetland converted to Cropland is now reported additionally to the types of land conversion reported in 2009 submission i.e. ;Grassland converted to Forest land, Wetland converted to Grassland, Grassland converted to Wetland, Other land converted to Wetland and Other land converted to Grassland. Due to limitations of present version of UNFCCC CRF-Reporter the Non-CO_2 emissions of Wetland converted to Grassland and of Revegetation are still reported under 5.G.

The QC/QA plan presented in the 2008 national inventory report has not been fully implemented with regard to LULUCF although some components of the plan have been included in the preparation of the inventory. Formal QC/QA procedures have not been prepared for LULUCF. The methods used for estimating emission/removal for individual sinks and sources are compliant with the AFOLU guidelines as described for relevant components below. In general Tier 1 QC are applied in preparation of the inventory for the LULUCF sector. Documentation of all the QC results is not included in preparation of the inventory as QC findings are corrected prior to submission, if possible. The remaining QC findings are reported in this report.

Accumulation and processing of land use information is revised implementing the definitions of land use categories and adopting new data. Area estimate for three categories previously estimated otherwise is now based on geographical information as described below. These categories are "Cropland remaining Cropland", "Wetland converted to Cropland" and "Wetland converted to Grassland". The processing of land use data is described below.

The reported emission for the LULUCF sector in 2008 is 1,997 Gg CO_2-eq compared to 1,212 Gg CO_2-eq for 2007 in 2009 submission. In this year's submission the estimated LULUCF emission for 2007 is 2,021 Gg CO_2-eq reflecting the recalculation effects. Emission from drained organic soil is now for the first time estimated separately for Cropland. This component now contributes 992 Gg CO_2-eq to the LULUCF sectors emission. The representative decrease in emission in category wetland converted to grassland due to less area is 265 CO_2-eq. Net increase in LULUCF emission is 727 Gg CO_2-eq. The increase in emission is due to higher emission factor used for Cropland than for Grassland. The N_2O emission due to the reallocation of this land is reported in 4D. Emission/removal estimates for Forest land is revised. Now carbon stock changes in mineral soil are included. The inclusion resulted in increased estimate of CO_2 removal of 45 Gg CO_2. For Forest land the removal increased from -80.0 Gg CO_2 eq (2009 submission) to -122.5 Gg CO_2-eq

(2010 submission) for the inventory year 2007 reflecting the effect of accounting for mineral soil.

7.2 Data Sources

The present CRF reporting is based on land use as recorded from IGLUD (Icelandic Geographical Land Use Database), activity data on afforestation and deforestation from Icelandic Forest Research (IFR) and on revegetation from the Soil Conservation Service of Iceland (SCSI). Data on liming is based on sold $CaCO_3$ and imported synthetic fertilizers containing chalk or dolomite.

The data sources and process of compiling the data to IGLUD will be described in details elsewhere (Guðmundsson et al. in prep). Provided below is a short description of the database, list of its main data sources, definitions of main land use categories as applied in IGLUD and present structure of subcategories.

7.2.1 The Icelandic Geographic Land Use Database (IGLUD)

7.2.1.1 Introduction

The objective of the Icelandic Geographic Land Use Database (IGLUD) is to compile information on land use and land use changes compliant to requirements of the 2006 IPCC Guidelines for National Greenhouse Gas Inventory (IPCC 2006). The categorization of land use also needs to be, as much as possible, based on existing information and adapted to Icelandic land use practices. Important criteria is that the land use practices most affecting the emission or removal of greenhouse gasses and changes in the extent of these practises are recognised by the database. The defined land use classes need to be as much as possible recognisable both through remote sensing and on ground. This applies especially to those categories not otherwise systematically mapped.

Another important objective of the IGLUD project is that all six main land use classes of IPCC Guidance should be geographically identified. Within the database, subdivisions of main land use categories should either be identified geographically or the relative division within a region or the whole country to be known. Relative division can be based on ground surveys or other additional information.

7.2.1.2 Land use practices and consequences

The dominant land use in Iceland through the ages has been that of livestock grazing. The natural birch woodland, widespread in the lowland at the time of settlement (AD 875), was exhausted for most part by the end of the 19^{th} century as a result of land clearance, intensive grazing, collection of firewood and charcoal making (Þórarinsson 1974). Following vegetation degradation, soil erosion became prevalent leading to the present day situation of highland areas having almost completely lost their soil mantle and large areas in the lowland regions being impacted by erosion as well (Arnalds et al. 2001).

Cultivation of arable land in Iceland has through the ages been very limited. Cereals (barley) were cultivated to some extent in the first centuries after settlement but completely ceased during the Little Ice-age. Due to better cultivars and warmer climate, grain cultivation has resurfaced in the last few decades (Hermannsson 1993). Livestock fodder, hay, was traditionally obtained from uncultivated grasslands and wetlands. With the mechanization of agriculture early in the 20th century farmers increasingly converted natural grasslands and wetlands into hayfields (Jónsson 1968).

In the period 1940-1990 massive excavation of ditches to drain wetlands took place, aided by governmental subsidies. Only a minor portion of these drained areas was converted to hayfields or cultivated. The larger part of the lowland wetlands in Iceland was turned into grassland through this drainage effort.

This land use history needs to be reflected in the national greenhouse gas inventory to the UNFCCC and also the actions taken to recover some of the lost resources. Definitions of land use categories, thus, need to differentiate between grassland of variable degradation stages and areas which are being restored either by direct activity as in re-vegetation efforts or due to decreased grazing pressure. Grassland and cropland formed by drainage also need to be separated from other land in these categories.

Ongoing land use changes in Iceland are not systematically recorded and consequently its direction or trend is generally unknown. Certain land use changes are although apparent. Among these are decreased grazing, enlargement of agricultural units and abandonment of others, urban spreading and introduction of new branches in farming. The major challenge of the IGLUD is to detect and quantify these changes.

7.2.1.3 Existing land use information

Geographical mapping of land use in Iceland has not been practiced to the same extent as in many European countries. Historically the farmlands were relatively large but only a small percentage cultivated. Use of commons, such as for summer grazing in the highlands, was based on orally inherited rules rather than written accounts. When written division existed it was generally based on references to names of identities in the landscape. Land use within each farm was entirely based on the decisions of the owner which in most cases was the residing farmer.

It is not until the 20th century that detailed countrywide mapping begins. First complete mapping of Iceland which included major landscape features and vegetation types was completed in 1943 (Landmælingar_Íslands 1943). Since then there have been ongoing efforts to map topography, vegetation, erosion and geology. Land use has only partially been mapped. Mapping of cultivated areas has been attempted a few times but never really completed. Settlements have been recorded on topographical maps and updated regularly. The first soil map of Iceland was produced in 1959 (Jóhannesson 1988). A new map was produced in the year

2000 and revised in 2001 (Arnalds and Gretarsson 2001) and again 2009 (Arnalds et al. 2009).

Total vegetation mapping started in 1955. The main objective was to estimate the grazing capacity of the land. The project was lead by the Icelandic Agricultural Research Institute and its precursors. The project was taken over by the Icelandic Institute of Natural History in 1995. Today, 2/3 of the country has been mapped for vegetation at scales ranging from 1:10,000 to 1:40,000.

Three inventories on natural birch woodland have been conducted, first in 1972-1975 then again in 1987-1991 and the third 2005-2009 as part of the New National Forest Inventory (NNFI). These maps have been digitised and rectified along with new maps of cultivated forest build on forest management maps and reports (Traustason and Snorrason 2008).

In the last two decades of the 20th century satellite images became available and opened up new opportunities in mapping. Several mapping projects were initiated in Iceland using this data. In the years 1991-1997 soil erosion was assessed and mapped and all farmland was mapped in 1998-2008 both vegetation types and grazing land conditions. This last mapping project is compiled in a digital geographical database (NYTJALAND) and forms the main data source for the IGLUD.

Iceland has become a formal partner of the European land use classification program CORINE. The National Land Survey of Iceland (NLSI) is responsible for Iceland's participation in the CORINE project. The first mapping, CORINE CLC-2006, was delivered in 2008. In 2009 NLSI finished mapping CLC 2000/2006 changes and integrating the changes to give CLC 2000.

The NYTJALAND full-scale 12 class (see Table 7.1) classification is not with complete coverage of Iceland. For the remaining areas a coarser classification (seven classes), has been carried out in relation with the CORINE project. IGLUD is based on this coarser classification where the full-scale NYTJALAND coverage is lacking.

In connection with the UNFCCC and KP reporting of the LULUCF sector, several existing maps have been developed further or initiated for the preparation of IGLUD. These maps include, map of forests, map of revegetated land, map of ditches, maps of drained land and map of cultivated land. Short description of these maps is provided below.

7.2.2 **Main data sources compiled in IGLUD**

The resulting classification of land use as presented in this submission is based on several sources the most important listed here:

7.2.2.1 NYTJALAND - Icelandic farmland database: Geographical database on condition of farming land

The Agricultural University of Iceland and its predecessor the Agricultural Research Institute in cooperation with other institutes, has for several years been working on a geographical database on the condition of vegetation on all farms in Iceland.

The full scale mapping is now completed for approximately 60% of the country, thereof is 70% of the lowlands below 400 m a.s.l. in Iceland. This geographical database is based on remote sensing using both ***Landsat 7*** and ***Spot 5*** images, existing maps of erosion and vegetation cover and various other sources. Extensive ground-truthing has resulted in a level of approximately 85% correct categorisation on less than 0.05 ha resolution. The categorization used divides the land into twelve classes, vegetation covers is ten classes and lakes, rivers and glaciers cover two. The definitions of categories are not the same as required for CRF LULUCF. The classes used in NYTJALAND are listed in Table 7.1.

The area not covered by full-scale classification of NYTJALAND was classified applying coarser classification (seven classes) modified according to CORINE requirements. Accordingly a two levels classification is available for the whole country, i.e. one with seven classes and full coverage of the country and another with 12 classes covering 60% of the country.

The pixel size in this database is 14×14 m and the reference scale is 1:30,000. The data was simplified by merging areas of a class covering less than 10 pixels to the nearest larger neighbour area, thus leaving 0.196 ha as the minimum mapping unit.

The two level NYTJALAND database is the primary data source of IGLUD.

Table 7.1 Land cover classes of the NYTJALAND database showing the full scale classes and the coarser class aggregation.

NYTJALAND full scale Classes (Icelandic name in brackets)	Short description	Coarse class name
Cultivated land (Ræktað land)	All cultivated land including hayfields and cropland.	Cropland and pasture
Grassland (Graslendi)	Land with perennial grasses as dominating vegetation including drained peat-land where upland vegetation has become dominating.	Grassland, heath-land shrubs and forest complex
Richly vegetated heath land (Ríkt mólendi)	Heath land with rich vegetation, good grazing plants common, dwarf shrubs often dominating, and mosses common.	Grassland, heath-land shrubs and forest complex
Poorly vegetated heath land (Rýrt mólendi)	Heath land with lower grazing values than richly vegetated heath land. Often dominated by less valuable grazing plants and dwarf shrubs, mosses and lichens apparent.	Grassland, heath-land shrubs and forest complex
Moss land (Mosi)	Land where moss covers more than 2/3 of the total plant cover. Other vegetation includes grasses and dwarf shrubs.	Grassland, heath-land shrubs and forest complex
Shrubs and forest (Kjarr og skóglendi)	Land where more than 50% of vertical projection is covered with trees or shrubs higher than 50 cm	Grassland, heath-land shrubs and forest complex
Semi-wetland- wetland upland ecotone- (Hálfdeigja)	Land where vegetation is a mixture of upland and wetland species. Carex and Equisetum species are common also dwarf shrubs. Soil is generally wet but without standing water. This category includes drained land where vegetation not yet dominated by upland species.	Semi-wetland/wetland complex
Wetland (Votlendi)	Mires and fens. Variability of vegetation is high but this class is dominated by Carex and Equisetum species and often shrubs.	Semi-wetland/wetland complex
Partially vegetated land (Hálfgróið)	Land where vegetation cover ranges between 20-50% . Generally infertile areas often on gravel soil. This class can both include areas where the vegetation is retreating or in progress.	Partly vegetated land
Sparsely vegetated land (Líttgróið)	Areas where less than 20 % of the vertical projection is covered with vegetation. Many types of surfaces are included in this class.	Sparely vegetated land
Lakes and rivers (Vötn og ár)	Lakes and rivers	Lakes and rivers
Glaciers (Jöklar)	Glaciers	Glaciers

7.2.2.2 CORINE CLC-2006

The National Land Survey of Iceland (NLSI) has, as responsible participant for Iceland in the European land use classification program CORINE, prepared a CLC-2006 map describing the 2006 land cover according to the CORINE classification. NYTJALAND was an important data source for the CLC-2006, and for the purpose of finishing CLC_2006 the gaps in NYTJALAND were closed by AUI with the coarser classification of SPOT 5 images taking in to account merging of classes as applied when converting NYTJALAND classes to CLC-2006. The CLC-2006 provides the data for the Settlement category. This year's submission is based on the 2009 revision of CLC-2006 Settlement map layer.

7.2.2.3 Maps of forests

All known forests including both the natural birch woodland and the cultivated forest have been mapped at the IFR on the basis of aerial photographs, satellite images and activity reports. These maps form the geographical background for the New National Forest Inventory (NNFI) carried out by IFR. The control and correction of these maps are part of the NNFI work. The category Forest land in IGLUD map is based on these maps.

7.2.2.4 Maps of land being revegetated

The SCSI collects information on revegetation activities. Majority of revegetation activities since 1990 are already mapped and available in a Geographical Information System (GIS). These maps form the geographical data background behind the national inventory of revegetation carried out by SCSI. The recorded activities which are currently not mapped are not included in the inventory but will be added as the data become available. The mapping of revegetation taking place before 1990 is less reliable with regard to activity, as the documentation emphasized on location rather than the activity. In last year's submission all land designated to revegetation, regardless of activity taking place or not, were included as Grassland subcategory of Revegetated land. In this year's submission the map of revegetation activity since 1990 plus the small fraction of revegetation before 1990 mapped are used instead to identify the Grassland subcategory "Revegetated land" in IGLUD.

7.2.2.5 Maps of Drained land

The AUI in cooperation with NLSI has, on basis of satellite images (SPOT 5) and support of aerial photographs, digitized all ditches in Iceland. The map of ditches and several map layers from NYTJALAND were used to produce a map of drained soils. The Grassland subcategory "Wetland converted to Grassland" is identified in IGLUD on basis of this map. (see Chapter 7.14)

7.2.2.6 Maps of cultivated land

Maps of cultivated land are also produced in cooperation with NLSI. The digitization was completed in 2009 by AUI. The maps prepared are used in IGLUD to identify the Cropland category. The area of drained organic soil within Cropland was mapped on basis of density analyses of the digitized ditches.

Besides these main sources of information several supplementary data sources and derived maps are used in the compilation of the land use classes in IGLUD. These supplementary data includes vegetation maps, road maps and geological maps. Derived maps include ditch density maps of cropland, drained land and roads with defined buffer zones. The map layers used in compiling the IGLUD map are listed in Table 7.2.

Table 7.2 List of map layers used in compiling the IGLUD map showing the categorization of layers and order of compilation.

Land use categories	Sub categories	Map layers included in land use category	ID	Order of compilation
1.Settlement		Discontinuous urban fabric	101	3
		Industrial, commercial units	102	4
		Harbours	103	5
		Airports	104	6
		Mines	105	7
		Dump sites	106	8
		Constructions sites	107	10
		Green urban areas	108	17
		Sport and leisure facilities	109	18
		Roads (1)	110	16
		Roads (2)	111	9
2.Forest land	Cultivated forest	Forest cultivations	201	14
		Forest cultivations 1960-1989	202	11
		Forest cultivations 2000-2008	203	13
		Forest cultivations 1990-1999	204	12
	Natural birch forest	Forest >2m	205	15
3.Cropland	Other cropland	Cropland	301	23
	Drained cropland	Cropland with ditch density 10-15 km km^{-2}	302	20
		Cropland with ditch density 15-20 km km^{-2}	303	21
		Cropland with ditch density > 20 km km^{-2}	304	22
4.Wetland	Other wetlands	Semi-wetland (wetland upland eco-tone)	401	42
		Wetland	402	43
		Semi-wetland/wetland complex	403	44
	Rivers and lakes	Rivers and lakes	404	19
	Reservoirs	Reservoirs	405	1
5.Grassland	Other grassland	Grassland (true grassland)	501	31
		Richly vegetated heath land	502	32
		Cultivated land	503	40
		Poorly vegetated heath land	504	33
		Mosses	505	35
		Partly vegetated land (1)	506	34
		Shrubs and forest	507	30
		Grassland, heath-land shrubs and forest complex	508	38
		Partly vegetated land (2)	509	39
		Cropland and pasture	510	41
		Natural birch Woodland <2m	516	29
		Revegetation area 1996-2008 with vegetation cover >33%	512	28
	Revegetated land	Revegetation before 1990	514	25
		Revegetation activity 1990-2008	515	24
		Farmers revegetation	511	26
	Drained grassland	Drained land	513	27
6.Other land	Other land	Historical lava fields with mosses (1)	601	36
		Historical lava fields with mosses (2)	602	37
		Sparely vegetated land (1)	603	46
		Sparely vegetated land (2)	604	47
		Revegetation area 1996-2008 with vegetation cover <33%	606	45
	Glaciers	Glaciers and perpetual snow	605	2

7.3 Definitions of Land use categories.

Definitions of the six main land use categories as they are applied in IGLUD are listed below, along with description of how they were compiled from the existing data.

7.3.1 Broad land use categories

Settlements[5]: All artificial areas larger than 0.5 ha and linear features >10 m, as defined in CORINE land cover classification. This category includes urban areas with >30% impermeable surface, industrial, commercial and transport units, mines, dumps and construction sites and artificial non-agricultural vegetated areas.

Forest land: All land, not included under Settlements, presently covered with trees or woody vegetation more than 2 m high, crown cover of minimum 10% and at least 0.5 ha in continuous area and minimum width 20 m and also land which currently fall below these thresholds, but *in situ* expected to reach these thresholds at mature state.

Cropland[6]: All cultivated land not included under Settlements or Forest land and at least 0.5 ha in continuous area and minimum width 20 m. This category includes harvested hayfields with perennial grasses.

Wetland: All land that is covered or saturated by water for all or part of the year and do not fall into the Settlements, Forest land, Cropland categories. It includes reservoirs as managed subdivision and natural rivers and lakes as unmanaged subdivision.

Grassland: All land where vascular plant cover is >20% and not included under the Settlements, Forest land, Cropland or Wetland categories. This category includes as subcategory land which is being revegetated and meeting the definition of the activity and does not fall into other categories. Drained wetlands not falling into other categories are included in this category as land being converted to Grassland.

Other land: This category includes bare soil, rock, glaciers and all land that does not fall into any of the other categories. All land in this category is unmanaged. This category allows the total of identified land area to match the area of the country.

Revegetation is not defined as subjected to one specific land use category according to the FCCC/CP/2001/13/Add.1, but as an activity. Revegetation as practiced in Iceland converts eroded or desertified land from “Other land” or less vegetated subcategories of Grassland to Grasslands or Grasslands with more vegetation cover. Revegetation activity can also result in such land being converted to Cropland, Wetland or Settlement. Forest land is excluded by definition.

[5] This definition is according to CORINE definition

[6] Definition according is to AFOLU guidelines (2006) with addition of 20 m minimum width and clarification on harvested hayfields.

Revegetation: A direct human-induced activity to increase carbon stocks on eroding or eroded/desertified sites through the establishment of vegetation or the reinforcement of existing vegetation that covers a minimum area of 0.5 hectares and does not meet the definitions of afforestation and reforestation.

7.3.2 Definition of sub-categories

All categories except “Other land” are, at least in theory, divided to managed and unmanaged land. Also requested in CRF, is the division of each category between, land remaining in relevant category and land being converted to that category, subdivided according to previous land use category. The division of the main land use categories to subcategories will be described in details elsewhere (Guðmundsson et al. in prep). The subdivisions implemented in this submission are defined below.

Settlement: No subdivision is used in this submission. The data used is divided into four subcategories according to CORINE land cover technical guide (Bossard et al. 2000) but reported as aggregated area.

Forest Land: Two subcategories are defined, natural birch forest and cultivated forest. The cultivated forests are further divided according to age of afforestation to forest land remaining forest land and land converted to forest land.

1. Natural birch forest: Forest where the dominant species is *Betula pubescens* that has regenerated naturally from sources of natural origin.
2. Plantations within natural birch forest.
3. Afforested land: Forest where planted or directly seeded trees or trees naturally generated from cultivated forests are dominant.
    a. Afforestation 1-50 years old: Afforestation is considered one year old the autumn the year planted[7]. This category is reported under Land converted to Forest land and stratified according to previous land use category.
    b. Afforestation older than 50 years: This category is reported under Forest land remaining Forest land.

Cropland: Cropland is divided on basis of drainage to Cropland remaining Cropland and Land converted to Cropland.

Wetland: Wetland category is subdivided into natural wetlands and reservoirs. The natural wetlands are divided further into three classes and the reservoirs are subdivided according to type of land being flooded.

1. Lakes and rivers
2. Mires and fens: This category includes peat land and mineral soil wetlands. In this year’s submission this category is reported as aggregated part of “other wetlands”.
3. Semi-wet areas: This category includes the ecotone between peat land and upland ecosystems. This land is often grazed by livestock and therefore considered managed. This land is one of the land cover classes of the

[7] For the inventory year 2007 plantations planted the years 1988-2007 are included.

NYTJALAND database. In this year's submission this category is reported as aggregated part of "other wetlands" along with "Mires and fens" land subcategory (2).

4. Reservoirs: Land minimum of 0.5 ha where freshwater is stored for hydropower or other purposes, behind artificial dams. The area of the reservoirs is subdivided according to the type of land flooded.
   - Lakes and rivers: This part of the reservoir area is classified as land remaining wetland.
   - Land with high soil organic carbon (SOC) >50 kg C m^2 (High SOC): This category includes land with organic soil or complexes of peatland and upland soils. This land is classified as land converted to Wetland or as changes between wetland subcategories. The high SOC soils are in most cases organic soils of peat lands or peat land previously converted to Grassland or Cropland through drainage.
   - Land with medium SOC 5-50 kg C m^2 (Medium SOC): This land includes most grassland, cropland and forestland soils except the drained wetland soils.
   - Land with low SOC < 5 kg C m^2 (Low SOC): This category includes land with barren soils or sparsely vegetated areas previously categorized under "Other land".

Grassland: This category is in this year's submission subdivided to three categories.

1. Grassland on drained wetland soils: This land is defined as previous wetland where the water table has been lowered permanently and now meets the classification criteria for Grassland. The land is identified on basis of existence of ditches or other drainage structures and reported as Wetland converted to Grassland.
2. Land being revegetated: All land recorded by the SCSI as land with Revegetation activity and not meeting the definitions of afforestation and reforestation or falls under Settlement, Cropland or Wetland. This land is reported as land being converted to Grassland subdivided according to land converted from. In this year's submission all land in this category is reported as Other land converted to Grassland although some areas might previously have been classified as grassland. SCSI estimates that <5% would belong to that category.
3. All other Grassland: This land is reported as Grassland remaining Grassland.

Other land: No subdivision of "Other land" is applied in this submission

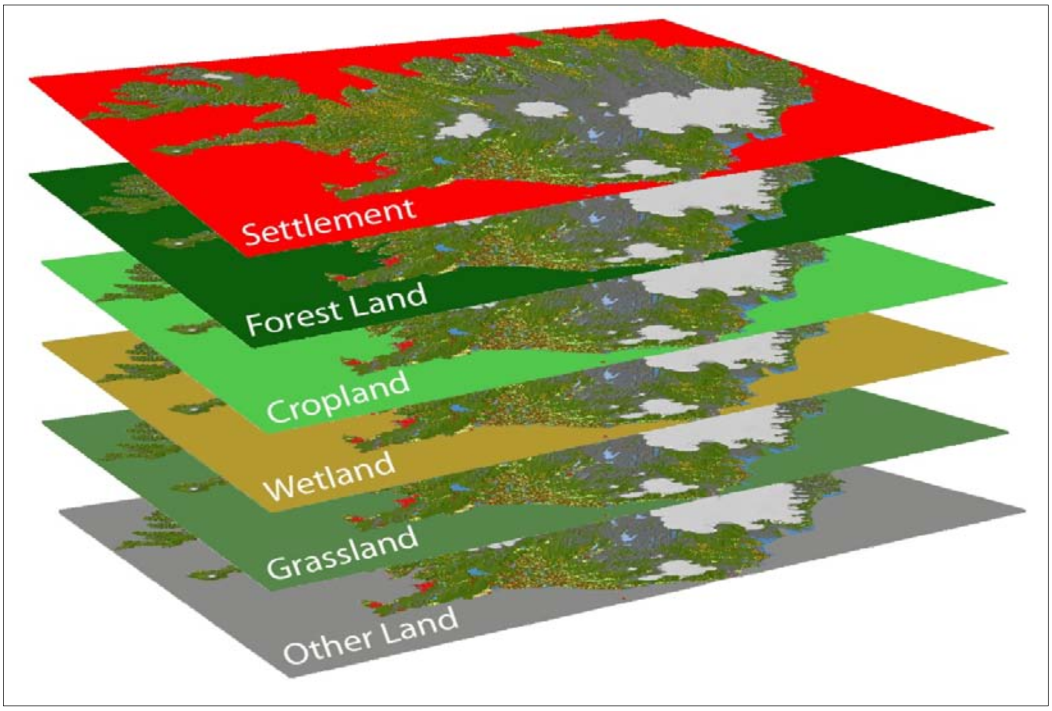

Figure 7.1 Hierarchy of land uses categories as included in the definitions of the categories

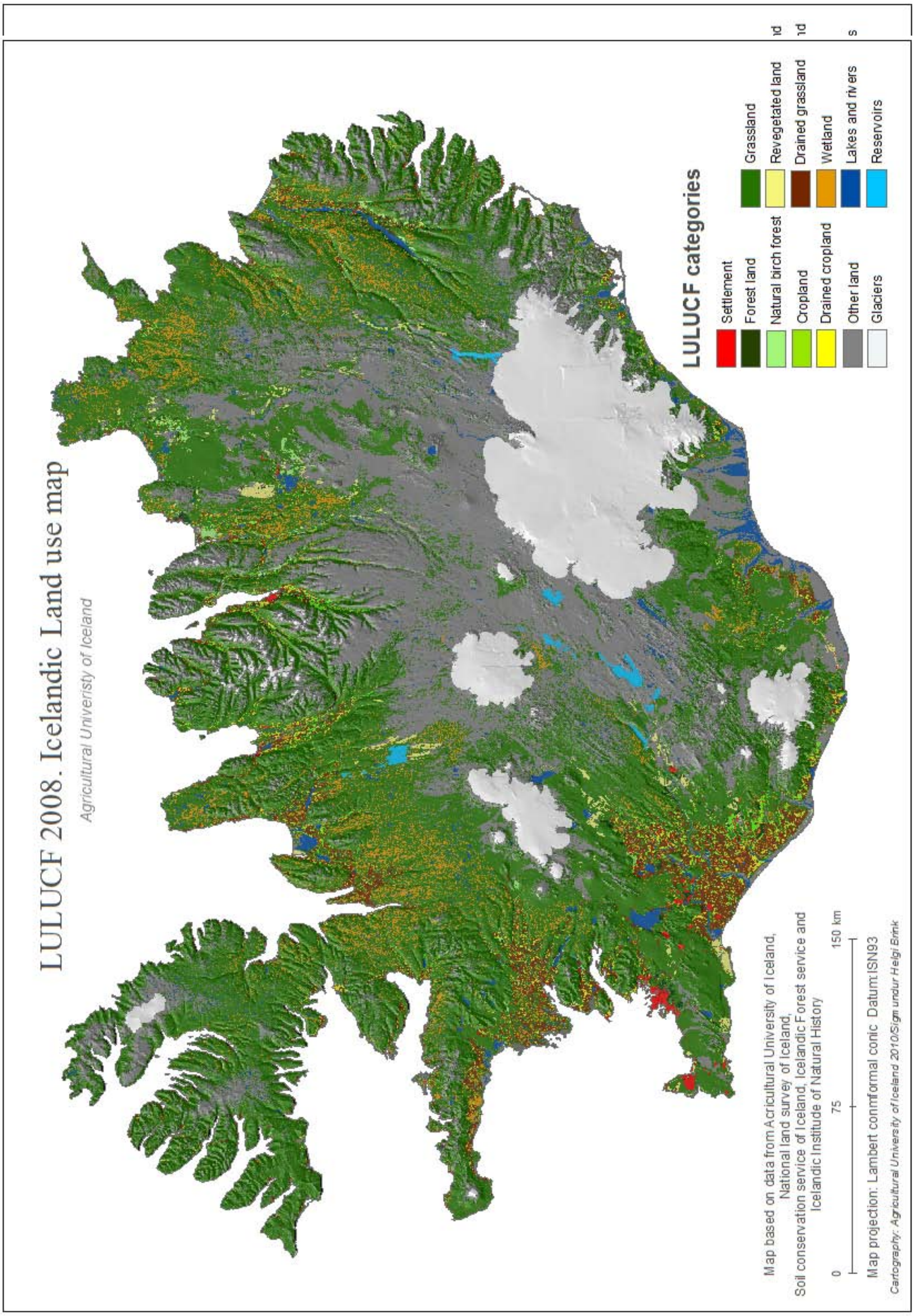

Figure 7.2 Map of Iceland showing the present status of land use classification in IGLUD

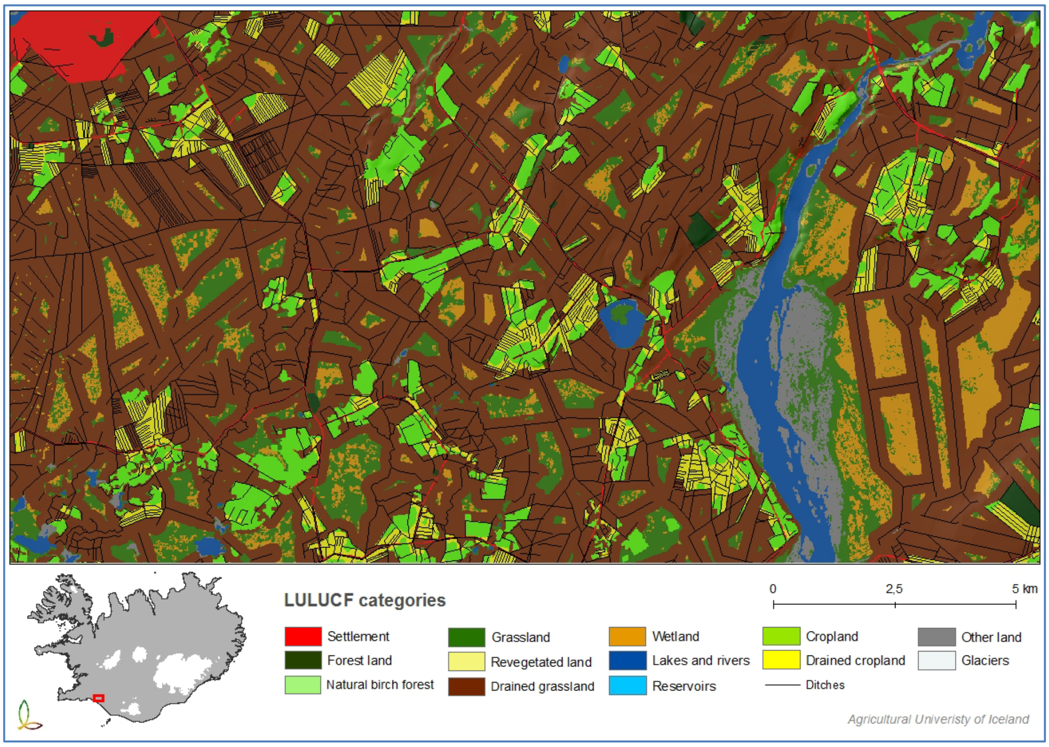

Figure 7.3 Enlarged map (I) showing details in IGLUD land use classification.

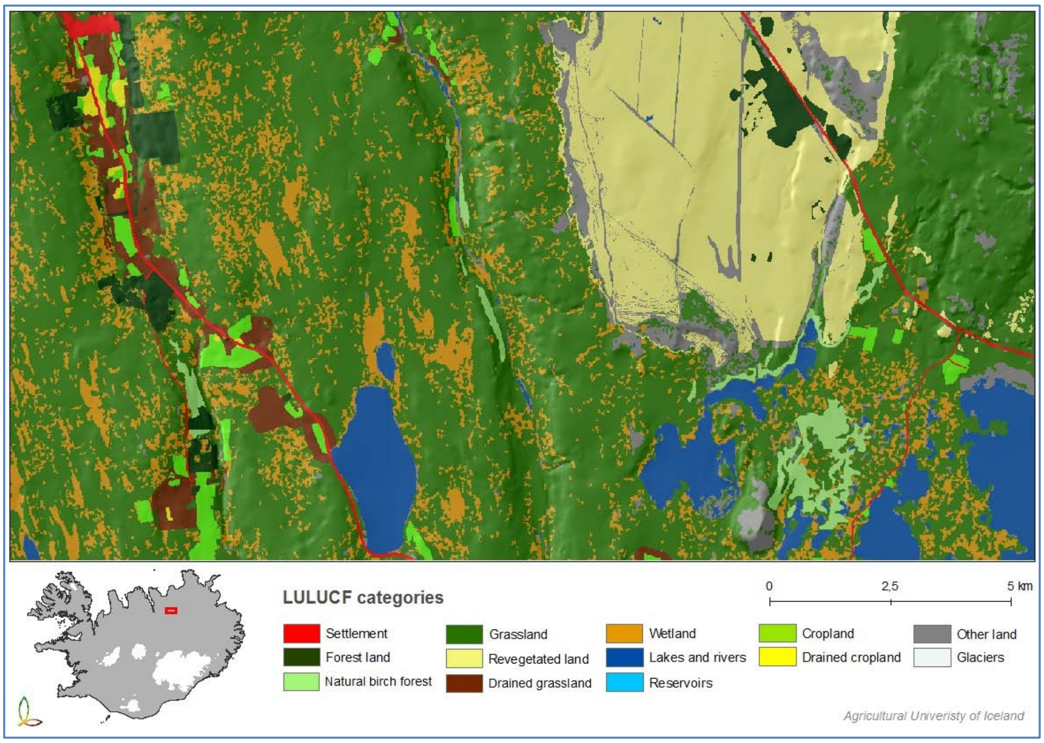

Figure 7.4 Enlarged map (II) showing details in IGLUD land use classification.

7.4 Land use map

Applying the definitions of land use categories the available maps were categorized to the relevant land use category. Considering the hierarchy of main land use categories, (Figure 7.1) overlaps of individual map layers, the logical dominance of map layers and the map accuracy, as estimated from information on map preparation, the order of compilation of the map layers was decided as listed in Table 7.2. The map layers were then compiled according to this order using ERDAS imaging 9.3, software and resulting layers grouped to estimate the total area of mapped land use categories

The resulting land use maps are shown in Figure 7.2, Figure 7.3 and Figure 7.4. The IGLUD is still under development and the maps produced are expected to develop considerable in coming years, including allocation of land between categories and to subcategories. The area of the land use categories as they appear in this map is used as basis for the area estimates used in the CRF. The land use categories and their area as they appear on the map are listed in Table 7.4. Also listed in the same table is the comparative area as applied in the CRF after the modification described below (see Chapter 7.5). The differences in these two area estimates, pinpoint the categories where either mapping or area estimate used for CRF needs to be revaluated. Solving these differences may include revised compilation of land use map-layers, improved mapping, adopting the mapping results in CRF, revision of method used for CRF area estimate or reallocation or subdivision of category area. In preparation of this year’s submission these methods were used to improve the coherences between the IGLUD maps and area reported in CRF.

7.5 Estimation of area of land use categories used in the CRF LULUCF tables.

The order of compilation of the map layers used in IGLUD has been revised from last submission. The order of compilation is listed in Table 7.2. The mapping of several categories has been improved considerably. This revision of maps and their compilation in IGLUD has resulted in map based area estimate of; Cropland, the portion of Cropland drained and drained Grassland. For the land use categories used in the CRF-LULUCF tables, where additional information on the category area is available and the information is ranked higher in reliability, they were used instead of mapped area. These changes in area were compensated by opposite change in other categories as described below.

Settlement: The Settlement category area is reported as estimated from the compilation of map layers in IGLUD.

Forest land: The area of Forest Land is estimated by the IFR through the New National Forest Inventory (see Chapter 7.12). The IFR also provides the maps for Forest land. The mapped areas differ from the NFI area estimate for both afforested land and natural birch forest applied in CRF. The area of Natural birch forest as reported by IFR is larger than the area of map layer of forest >2 m as resulting from the compilation process of IGLUD as the area reported by IFR includes areas where the forest is still under 2m but expected to reach that height *in situ* at maturity. In the compilation process all land mapped as afforested land are excluded due to their higher ranking in the compilation order. The difference in area is balanced against area of the Grassland map layer “Natural birch woodland <2 m”, i.e. difference in area is subtracted from the area of "Natural birch woodland < 2 m". The area of cultivated forest is reported smaller than the land mapped as cultivated forest (see Chapter 7.12). To correct for the effects on area of those categories estimated from IGLUD mapping two corrections were done. Firstly the overlap of mapped cultivated forest with those lower ranking map layers in the compilation order, which GHG emission/removal is estimated for, was estimated. The proportion of the difference in area overlapping these categories was added to these categories accordingly. Secondly the remaining difference in area was added un-specified to the area of Grassland. Subdivision of forest land to organic and mineral soil and to previous land use is according to IFR unpublished data from the national forest inventory. Allocation of land to subcategories is according to information provided by the IFR.

Cropland: The area of Cropland used in CRF is for the first time in this year's submission based on IGLUD map area. The area of drained cropland, reported as "Wetland converted to Cropland" is also estimated from IGLUD maps. The categories are identified on basis of two map layers i.e. map of ditches and map of cultivated land. The network of ditches was analysed with regard to aerial density of the network and all land where the density of ditches was higher than 10 km/km^2 were categorized as Wetland converted to Cropland.

Wetland: The total area of the Wetland category used in CRF was obtained from IGLUD. This category is reported as three subcategories i.e. Reservoirs, Lakes and Rivers, and Other wetlands. The area of Reservoirs used in CRF was obtained from the companies running the reservoirs. This area is compared to the mapped area of reservoirs in IGLUD the difference is balanced against the area of lakes and rivers in IGLUD.

Grassland: The total area of the Grassland category used in CRF is the area identified in IGLUD plus the area added due to difference in Forest Land map layer and CRF area as described above and correction for unmapped revegetation. Only a small portion of revegetation activities before 1990 is mapped. All that area is assumed to be detected as vegetated land and accordingly included in the map layers from NYTJALAND compiled to the grassland category and no correction toward other categories were executed. The area mapped as revegetation activity 1990-2008 is smaller than the area reported in CRF (not entirely based on mapped areas). Half of the difference is assumed to be already included in Grassland category and half to be mapped in IGLUD as other land and subtracted accordingly. The map layer Drained land was prepared from map of ditches applying 200 m buffer zone on every ditch. From that area the overlap with following map layers was excluded; Sparsely vegetated land (ID in Table 7.2: 603 and 604), Partly vegetated land (ID: 506 and 509), Lakes and Rivers (ID: 404), Shrubs and forest (ID: 507) and Natural birch woodland <2 m (ID: 516). Additionally all areas where slope exceeded 10° and all areas extended below seashore line were excluded. To exclude steep areas the AUI elevation model (unpublished), based on NLSI elevation maps, was used. The map layer of drained land so prepared was used in the IGLUD compilation process and further limited by the map layers ranking higher in compilation order. The part of

Forest Land mapped area exceeding reported area was added directly to the area of drained land as described above. It is estimated that 98% of the mapped drained areas are with organic soils based on soil samples taken randomly within 100 m from ditches in West Iceland. (AUI unpublished data)

Other Land: The area estimate of IGLUD with the above described corrections is used in the CRF. Additionally in the IGLUD map glaciers and perpetual snows are mapped especially

The area estimates of land use categories in IGLUD and CRF are listed in Table 7.3. In Table 7.4 the area of all categories and subcategories reported are listed along with the area of organic soil included.

Table 7.3 Area of land use categories as mapped in IGLUD and as applied in CRF-tables.

Mapped area	Area kha	Comparable area as reported in CRF	Area kha
Settlement	71.06	Settlement	71.06
Forest Land	97.25	Forest Land	87,84
Natural birch forest	24.76	Natural birch forest	53.46
Cultivated forest	46.20	Cultivated forest total	34,38
Cropland	169.14	Cropland	169.23
Drained Cropland	55.11	WL converted to CL	55.20
Other Cropland	114.03	CL remaining CL	114.03
Wetland	631.22	Wetland	631.22
Lakes and Rivers	200.47	Lakes and rivers	188.18
Reservoirs	32.48	Reservoirs	44.77
Other wetlands	398.27	Other wetlands	398.27
Grassland	5,303.69	Grassland	5,299.75
Drained grassland	340.04	WL converted to GL	342.37
Revegetated land (RL)	76.04	OL converted to GL	199.45
RL before 1990	1.45	RL before 1990	98.81
RL since 1990	74.59	RL since 1990	100.65
Other Land	4,043.28	Other Land	4,030.25
Glaciers and perpetual snow	1,113.33	Glaciers and perpetual snow	Not rep

7.6 Time series

Time series are lacking for most land use categories. There are only three categories where time series are based on yearly land use information, i.e. cultivated forest, revegetation activity and reservoirs. All other reported time series on land use are derivates of these time series.

7.7 Land use changes

Emission/removal of GHG due to land use changes is reported for eight types of land conversions, i.e. Grassland to Forest land, Other land to Forest land, Wetland to Cropland, Wetland to Grassland, Other land to Grassland, Grassland to Wetland, Other land to Wetland and Forest land to Settlement.

The conversion period varies between categories as explained in relevant chapters below. Recording of land use changes is still limited in Iceland and only available for few of the land use categories requested in CRF. In preparing this submission 47 map layers were prepared Table 7.2. The accuracy of many map layers still needs to be ascertained. Many of these map layers e.g. those originating from the full scale NYTJALAND classification were tested in extensive ground truth project. The current validity of that ground truth data remains to be assessed. Gradual updating of the maps and comparison with older maps and land use data is expected to provide better estimate for land use changes than is currently available.

7.8 Uncertainties QA/QC

New order of compilation of the map layers, inclusion of new data and revision of other map layers in IGLUD is considered to have improved the quality of the land use data compared to previous submission. All map layers used have been visually controlled by the AUI GIS laboratory staff during the preparation process and compared to local knowledge. This internal quality control has lead to exclusion of many faults arising during the process establishing good confidence in the maps. This control is still only qualitative.

Table 7.4 Land use classification used in GHG inventory 2008 submitted 2010 and the total area and the area of organic soil of each category

Land-Use Category	Sub-division	Area (kha)	Area of organic soil (kha)
Total Forest Land		87.84	2.53
Forest Land remaining Forest Land		54.87	
	Afforestation older than 50 years	0.42	
	Natural Birch forest	53.46	
	Plantation in natural birch forest	0.98	
Land converted to Forest Land		32.98	2.53
Grassland converted to Forest Land		29.10	2.53
	Afforestation 1-50 years old	29.10	2.53
Other Land converted to Forest Land		3.88	
	Afforestation 1-50 years old	3.88	
Total Cropland		169.23	54.09
Cropland remaining Cropland		114.03	
Land converted to Cropland		55.20	54.09
Wetlands converted to Cropland		55.20	54.09
Total Grassland		5,299.75	335.52
Grassland remaining Grassland		4,757.93	
Land converted to Grassland		541.82	335.52
Wetlands converted to Grassland		342.37	335.52
Other Land converted to Grassland		199.45	
	Revegetation before 1990	98.81	
	Revegetation since 1990	100.65	
Total Wetlands		631.22	
Wetlands remaining Wetlands		605.96	
	Lakes and rivers	188.18	
	Other wetlands	398.27	
	Reservoirs	19.51	
Land converted to Wetlands		25.26	
Grassland converted to Wetlands		9.97	
	High SOC	3.28	
	Medium SOC	6.69	
Other Land converted to Wetlands		15.29	
	Low SOC	15.29	
Total Settlements		71.06	
Settlements remaining Settlements		71.06	
Total Other Land		4,030.25	
Other Land remaining Other Land		4,030.25	

All map layers originating from the full scale classification have been controlled through extensive ground truthing process. The map layers of Settlement are based on ground mapping of individual municipal planning authorities and the maps of forestry and revegetation are prepared through mixture of, on *in situ* mapping, remote sensing and on screen mapping. Quantitative estimate of mapping uncertainty is though still not available. Tracking back the changes in area of the land use categories on basis of the few time series provided is still highly uncertain as in previous submissions.

7.9 Planned improvements regarding land use identification and area estimates.

The IGLUD database compiles land use data obtained through remote sensing, GIS mapping and field surveys on land use. Repeated land classification based on new satellite images through remote sensing, updating and improving GIS-maps and continuing field surveys is included in the IGLUD project. The project is thus expected to gradually provide new land use data and improve the existing data. Important part of data sampling for the land use database is to obtain information on various C-pools in each land use category. Data for estimating the size of different C-pools of the land use categories is therefore expected to be available in the coming years.

As participant in the CORINE mapping project NLSI has delivered CLC 2006. In summer 2009 CLC 2000/2006 changes were delivered and also their integration to CLC 2000. These maps identify changes in at least some of the land use categories applied in the CRF. This mapping effort has provided data on land use changes which will be used to establish time series.

There are several projects related to individual land use categories, which are designed to improve the quality of their area estimates. These are described in their relevant following chapters.

7.10 Completeness and method

Based on the above described accumulation of land use data and emission factors or C-stock changes the emission by source and removal by sinks were calculated.
Summary of method and emission factors used is provided in Table 7.5, Table 7.6 and Table 7.7.

Table 7.5 Summary of method and emission factors applied on CO_2 emission calculation. EF = emission factor, D = default (IPCC), CS = country specific, RA= reference approach, NA = not applicable, NE= not estimated, NO = not occurring, IE=included elsewhere, T1 = Tier 1, T2 = Tier 2 and T3 = Tier 3,

		CO_2		
Source/sink	Area (kha)	Method	EF	Gg Emission/ Removal (-)
Forest Land remaining Forest Land	**54.87**			**-11.60**
Afforestation older than 50 years	**0.42**	**T3**	**CS**	**-1.95**
-Living biomass		**T3**	**CS**	**-1.95**
-Dead organic matter		**NE**		
-Soils				
Mineral soil		**NE**		
Organic soil	**NO**			
Natural Birch forest	**53.46**	**NE**		
Plantations in natural birch forest	**0.98**			**-9.65**
-Living biomass		**T3**	**CS**	**-9.65**
-Dead organic matter		**NE**		
-Soils				
Mineral soil		**NE**		
Organic soil	**NO**			
Land converted to Forest Land	**32.98**			
Grassland converted to Forest Land	**29.10**			**-110.46**
Afforestation 1-50 years old	**29.10**			**-110.46**
-Living biomass		**T3**	**CS**	**-76.35**
-Dead organic matter		**NE**		
-Soils				
Mineral soil	**26.57**	**T2**	**CS**	**-35.60**
Organic soil	**2.53**	**T1**	**D**	**1.49**
Other Land converted to Forest Land	**3.88**			
Afforestation 1-50 years old	**3.88**			**-13.15**
-Living biomass		**T3**	**CS**	**-3.55**
-Dead organic matter		**NE**		
-Soils				
Mineral soil	**3.88**	**T2**	**CS**	**-9.60**
Organic soil	**NO**			
Cropland remaining Cropland	**114.03**	**NE**		
Land converted to Cropland	**55.20**			
Wetlands converted to Cropland	**55.20**			**991.72**
-Living biomass		**NE**		
-Dead organic matter		**NE**		

Table continues				
Continued Table		CO_2		
Source/sink	Area (kha)	Method	EF	Gg Emission/ Removal (-)
-Soils				
Mineral soil	**1.10**	**NE**		
Organic soil	**54.09**	**T1**	**D**	**991.72**
Grassland remaining Grassland	**4,757.93**	**NE**		
Land converted to Grassland	**541.82**			
Wetlands converted to Grassland	**342.37**			**1,353.27**
-Living biomass		**NE**		
-Dead organic matter		**NE**		
-Soils				
Mineral soil	**6.85**	**NE**		
Organic soil	**335.52**	**T2**	**CS/(D)**	**1,353.27**
Other Land converted to Grassland	**199.45**			
Revegetation before 1990	**98.81**			**-271.71**
-Living biomass		**T2**	**CS**	**-27.17**
-Dead organic matter		**IE**		
-Soils				
Mineral soil	**98.81**	**T2**	**CS**	**-244.54**
Organic soil	**NO**			
Revegetation since 1990	**100.65**			**-276.77**
-Living biomass		**T2**	**CS**	**-27.68**
-Dead organic matter		**IE**		
-Soils				
Mineral soil	**100.65**	**T2**	**CS**	**-249.10**
Organic soil	**NO**			
Wetlands remaining Wetlands	**605.96**	**NE**		
Lakes and rivers	**188.18**	**NE**		
Other wetlands	**398.27**	**NE**		
Reservoirs	**19.51**	**NE**		
Land converted to Wetlands	**25.26**			**16.18**
Grassland converted to Wetlands	**9.97**			**15.82**
High SOC CO_2	**3.28**	**RA/T2**	**CS**	**9.11**
Medium SOC CO_2	**6.69**	**RA/T2**	**CS**	**6.72**
Other Land converted to Wetlands	**15.29**			**0.36**
Low SOC CO_2	**15.29**	**RA/T2**	**CS**	**0.36**
Settlements remaining Settlements	**71.06**	**NA**		
Other Land remaining Other Land	**4,030.25**	**NA**		

Table 7.6 Summary of method and emission factors applied on CH_4 emission calculations. EF = emission factor, D = default (IPCC), CS = country specific, *RA= reference approach,* NA = not applicable, NE= not estimated, NO = not occurring, IE=included elsewhere, T1 = Tier 1, T2 = Tier 2 and T3 = Tier 3

		CH_4			
Source/sink	**Area**			**Gg Emission/**	
	kha	**Method**	**EF**	**Removal (-)**	**Gg CO2 eq**
Wetlands remaining Wetlands	605.96				
Lakes and rivers	188.18	NE			
Other wetlands	398.27	NE			
Reservoirs	19.51	NA			
Land converted to Wetlands	25.26			0.66	13.92
Grassland converted to Wetlands	9.97			0.65	13.63
High SOC CH_4		RA/T2	CS	0.38	7.89
Medium SOC CH_4		RA/T2	CS	0.27	5.73
Other Land converted to Wetlands	15.29			0.01	0.30
Low SOC CH_4		RA/T2	CS	0.01	0.30

Table 7.7 Summary of method and emission factors applied on N_2O emission calculations. EF = emission factor, D = default (IPCC), CS = country specific, *RA= reference approach,* NA = not applicable, NE= not estimated, NO = not occurring, IE=included elsewhere, T1 = Tier 1, T2 = Tier 2 and T3 = Tier 3,

		N_2O			
Source/sink	**Area**			**Gg Emission/**	
	kha	**Method**	**EF**	**Removal (-)**	**Gg CO2 eq**
Forest Land remaining Forest Land	54.87	NE			
Land converted to Forest Land	32.98				
N2O fertilizers		T1	D	0.00	0.11
Grassland converted to Forest Land					
- Soils					
Mineral Soil	30.45	NE			
Organic Soils N2O	2.53	T1	D	0.00	0.74
Cropland remaining Cropland	114.03	NE			
Land converted to Cropland	55.20				
- Soils					
Mineral Soil	1.10	NE			
Organic Soils N2O	54.09	IE			
Grassland remaining Grassland	4,757.93	NE			
Land converted to Grassland(12)	541.82				
Wetlands converted to Grassland	342.37				
- Soils					
Mineral Soil	6.85	NE			
Organic Soils N2O	335.52	T1	D	0.95	294.20
Other Land converted to Grassland	199.45				
N2O fertilizers		T1	D	0.01	4.53

7.11 LULUCF key sources/sink and key areas

Of all the sources/sinks as calculated for each subcategory, six were recognized as LULUCF level key source with regard to CO_2 equivalents Table 7.8. Non-estimated categories cannot be excluded as a potential level key source.

Table 7.8 LULUCF level key source assessment of land use categories, for which emissions/removals were calculated

		CO_2 equivalent Gg			
Source/sink	**Direct GHG emission/ removal (-)**	**Absolute value category**	**level %**	**Cumulative level %**	**Key source/ sink**
Wetlands converted to Grassland- organic soil CO2	1,353.27	1,353.27	40.19	40.19	x
Wetlands converted to Cropland -organic soil CO2	991.72	991.72	29.46	69.65	x
Wetland converted to Grassland Non-CO2 emission - N2O drainage - Organic Soil -N2O	0.95	294.20	8.74	78.39	x
Other Land converted to Grassland -Revegetation since 1990- mineral soil CO2	-249.10	249.10	7.40	85.79	x
Other Land converted to Grassland -Revegetation before 1990 -mineral soil CO2	-244.54	244.54	7.26	93.05	x
Grassland converted to Forest Land -Afforestation 1-50 years old- living biomass	-76.35	76.35	2.27	95.32	x
Grassland converted to Forest Land -Afforestation 1-50 years old-mineral soil	-35.60	35.60	1.06	96.37	
Other Land converted to Grassland -Revegetation since 1990 -living biomass	-27.68	27.68	0.82	97.20	
Other Land converted to Grassland -Revegetation before 1990 -living biomass	-27.17	27.17	0.81	98.00	
Forest Land remaining Forest Land -Plantations in natural birch forest- living biomass	-9.65	9.65	0.29	98.29	
Other Land converted to Forest Land -Afforestation 1-50 years old-mineral soil	-9.60	9.60	0.29	98.57	
Grassland converted to Wetlands -High SOC -CO2	9.11	9.11	0.27	98.84	
Flooded Lands CH4 -High SOC -CH4	0.38	7.89	0.23	99.08	
Grassland converted to Wetlands -Medium SOC -CO2	6.72	6.72	0.20	99.28	
Flooded Lands CH4 -Medium SOC -CH4	0.27	5.73	0.17	99.45	
Other emissions due to Revegetation activities -N2O fertilizers	0.01	4.53	0.13	99.58	
Other Land converted to Forest Land -Afforestation 1-50 years old- living biomass	-3.55	3.55	0.11	99.69	
Cropland -lime CO2 -shellsand (90% CaCO3)	2.37	2.37	0.07	99.76	
Forest Land remaining Forest Land -Afforestation older than 50 years-living biomass	-1.95	1.95	0.06	99.82	
Cropland -lime CO2 -Limestone CaCO3	1.89	1.89	0.06	99.87	
Grassland converted to Forest Land -Afforestation 1-50 years old-organic soil CO2	1.49	1.49	0.04	99.92	
Cropland -lime CO2 -Dolomite CaMg(CO3)2	1.26	1.26	0.04	99.96	
Forest Land N2O drainage - Organic Soil -N2O	0.00	0.74	0.02	99.98	
Other Land converted to Wetlands -Low SOC -CO2	0.36	0.36	0.01	99.99	
Flooded Lands CH4 -Low SOC -CH4	0.01	0.30	0.01	100.00	
Land converted to Forest Land -N2O fertilizers	0.00	0.11	0.00	100.00	
Total		**3,366.87**			

Too much subdivision of sources can obscure the contribution of land use categories. Therefore the contributions within each main land use category were added and the total contribution assessed Table 7.9. Three main land use categories were recognized as key sources.

Table 7.9 LULUCF level key source assessment of total absolute values within main land use categories, for which emissions/removals were calculated

		CO_2 equivalents Gg			
Source/sink		**Sum of absolute values**			
Main land-use category	**Area(2) (kha)**	**Main category**	**Level %**	**Cumulative level %**	**Key source**
Land converted to Grassland	541.82	2,200.49	65.36	65.36	x
Land converted to Cropland	55.20	991.72	29.46	94.81	x
Land converted to Forest Land CO_2	32.98	127.43	3.78	98.60	x
Land converted to Wetlands	25.26	30.11	0.89	99.49	
Forest Land remaining Forest Land	54.87	11.60	0.34	99.84	
Cropland remaining Cropland	114.03	5.52	0.16	100.00	
		3,366.87			

Trend key source assessment for LULUCF was not performed as independent time series are not available for most of the categories. Considering the present status of land use information the key land use categories on basis of area were assessed. This key area assessment was performed to identify the most important land use categories on basis of their area. On the land use categories as reported two assessments were performed; the highest resolution area subcategories (Table 7.10) and on main land use categories (Table 7.11). Including highest resolution area subcategories, six were recognised as key areas, two of which are by definition unmanaged and no emission is reported for i.e.; “Other land remaining other land” and “Lakes and rivers”. A third category recognised as key area, i.e. Other wetlands is an aggregate of two subcategories “Mires and fens” and “Semi-wet areas” where the former is mostly unmanaged. No emissions are presently reported for subcategory “Semi-wet areas”. No emissions are presently estimated for Grassland remaining Grassland or for Cropland remaining Cropland. This leaves only one of the categories recognised as key area considering all subcategories, where emissions are estimated i.e. “Wetland converted to Grassland- Organic soils”. Considering only main land use categories four are recognized as key area i.e.; Other land remaining Other land, Grassland remaining Grassland, Wetlands remaining Wetland and Land converted to Grassland (Table 7.11). Emissions are presently only estimated for one of these categories.

An additional area assessment was carried out, considering only applicable land use categories excluding the category other land and other categories which as by definition unmanaged and emission/removal calculation not applicable.

Considering only applicable land use categories, (Table 7.12) two additional land use categories are assessed as key areas, compared to those included when all categories reported at highest area resolution were considered. These categories were, "Other land converted to Grassland –Revegetation before 1990" and "Other land converted to Grassland –Revegetation since 1990".

Table 7.10 LULUCF area level assessment of land use categories for highest area resolution reported. Key areas are those contributing to 95% cumulative level on the list of land use categories listed from largest to smallest.

Land-use category at highest reported resolution	Area (kha)	Area level %	Cumulative level %	Key area
Grassland remaining Grassland	4,757.93	46.24	46.24	x
Other Land remaining Other Land	4,030.25	39.17	85.41	x
Wetlands remaining Wetlands -Other wetlands	398.27	3.87	89.28	x
Wetlands converted to Grassland- organic soil	335.52	3.26	92.54	x
Wetlands remaining Wetlands -Lakes and rivers	188.18	1.83	94.37	x
Cropland remaining Cropland	114.03	1.11	95.48	x
Other Land converted to Grassland - Revegetation since 1990	100.65	0.98	96.46	
Other Land converted to Grassland - Revegetation before 1990	98.81	0.96	97.42	
Settlements remaining Settlements	71.06	0.69	98.11	
Wetlands converted to Cropland -organic soil	54.09	0.53	98.63	
Forest Land remaining Forest Land -Natural Birch forest	53.46	0.52	99.15	
Grassland converted to Forest Land - Afforestation 1-50 years old-mineral soil	26.57	0.26	99.41	
Wetlands remaining Wetlands -Reservoirs	19.51	0.19	99.60	
Other Land converted to Wetlands -Low SOC	15.29	0.15	99.75	
Wetlands converted to Grassland- mineral soil	6.85	0.07	99.82	
Grassland converted to Wetlands -Medium SOC	6.69	0.07	99.88	
Other Land converted to Forest Land - Afforestation 1-50 years old	3.88	0.04	99.92	
Grassland converted to Wetlands -High SOC	3.28	0.03	99.95	
Grassland converted to Forest Land - Afforestation 1-50 years old-organic soil CO2	2.53	0.02	99.98	
Wetlands converted to Cropland -mineral soil	1.10	0.01	99.99	
Forest Land remaining Forest Land - Plantations in natural birch forest- living biomass	0.98	0.01	100.00	
Forest Land remaining Forest Land - Afforestation older than 50 years	0.42	0.00	100.00	
	10,289.35			

Assessment of level key area points out the areas which should be emphasized both regarding improved area estimate and due to their relatively large area the emission estimate needs to be improved.

No systematic assessment has been carried out regarding trend in land use changes. Considering only the information presented in this inventory, two land use changes are most important considering both the area involved and emissions or removals reported. These land use changes are conversions of Wetlands and Other land to Grassland.

Table 7.11 LULUCF area level assessment of main land use categories. Key areas are those contributing to 95% cumulative level on the list of land use categories listed from largest to smallest.

Main land-use category	Area(2) (kha)	Area level %	Cumulative level %	Key area
Grassland remaining Grassland	4,757.93	46.24	46.24	x
Other Land remaining Other Land	4,030.25	39.17	85.41	x
Wetlands remaining Wetlands	605.96	5.89	91.30	x
Land converted to Grassland	541.82	5.27	96.57	x
Cropland remaining Cropland	114.03	1.11	97.67	
Settlements remaining Settlements	71.06	0.69	98.36	
Land converted to Cropland	55.20	0.54	98.90	
Forest Land remaining Forest Land	54.87	0.53	99.43	
Land converted to Forest Land	32.98	0.32	99.75	
Land converted to Wetlands	25.26	0.25	100.00	
	10,289.35			

Table 7.12 LULUCF area level assessments of land use categories considered relevant as potential source/ sinks and where area was identified. Key areas are those contributing to 95% cumulative level on the list of land use categories listed from largest to smallest.

Applicable land-use categories	Area (kha)	Area level %	Cumulative level %	Key area
Grassland remaining Grassland	4,757.93	78.37	78.37	x
Wetlands remaining Wetlands -Other wetlands	398.27	6.56	84.93	x
Wetlands converted to Grassland- organic soil	335.52	5.53	90.46	x
Cropland remaining Cropland	114.03	1.88	92.34	x
Other Land converted to Grassland -Revegetation since 1990	100.65	1.66	94.00	x
Other Land converted to Grassland -Revegetation before 1990	98.81	1.63	95.62	x
Settlements remaining Settlements	71.06	1.17	96.79	
Wetlands converted to Cropland -organic soil	54.09	0.89	97.68	
Forest Land remaining Forest Land -Natural Birch forest	53.46	0.88	98.57	
Grassland converted to Forest Land -Afforestation 1-50 years old-mineral soil	26.57	0.44	99.00	
Wetlands remaining Wetlands -Reservoirs	19.51	0.32	99.32	
Other Land converted to Wetlands -Low SOC	15.29	0.25	99.58	
Wetlands converted to Grassland- mineral soil	6.85	0.11	99.69	
Grassland converted to Wetlands -Medium SOC	6.69	0.11	99.80	
Other Land converted to Forest Land -Afforestation 1-50 years old	3.88	0.06	99.86	
Grassland converted to Wetlands -High SOC	3.28	0.05	99.92	
Grassland converted to Forest Land -Afforestation 1-50 years old-organic soil CO2	2.53	0.04	99.96	
Wetlands converted to Cropland -mineral soil	1.10	0.02	99.98	
Forest Land remaining Forest Land -Plantations in natural birch forest- living biomass	0.98	0.02	99.99	
Forest Land remaining Forest Land -Afforestation older than 50 years	0.42	0.01	100.00	
	6,070.93			

7.12 Forest land

In accordance to the GPG arising from the Kyoto Protocol a country-specific definition of forest has been adopted. The minimal crown cover of forest is 10%, the minimal height 2 m, minimal area 0.5 ha and minimal width 20 m. This definition is also used in the New National Forest Inventory (NNFI). Further description of forest definition will be found in a methodological report of carbon accounting of forests (Snorrason in prep). All forest, both naturally regenerated and planted, is defined as managed as it is all directly affected by human activity. The natural birch woodland has been under continuous usage for ages. Until the middle of the last 19th century it was the main source for fuel wood for house heating and cooking in Iceland (Ministry for the Environment 2007). Most of the woodland was used for grazing and still is although some areas have been protected from grazing.

Natural birch woodland is included in the IFR new national forest inventory (NNFI). In NNFI the natural birch woodland is defined as one of the two predefined strata to be sampled. The other stratum is the cultivated forest consisting of tree plantation, direct seeding or natural regeneration originating from cultivated forest. The sampling fraction in the natural birch woodland is lower than in the cultivated forest. Each 200 m^2 plot represents 1.5 x 3.0 km^2 (Snorrason in prep). On basis of new data from NNFI the area of natural birch woodlands has been revised from last submission. The part of natural birch woodland defined as forest (reaching 2 m or greater in height at maturity *in situ*) is revised on basis of new data obtained through the last year of five in the first national forest inventory. New estimate of the area is now 53.46 kha ± 7.6 kha 95% CL) instead of 48 kha (± 8 kha 95% CL) in last submission.

In a chronosequence study (named ICEWOODS research project) where afforestation areas of the four most commonly used tree species of different age where compared in eastern and western Iceland, the results showed significant increase in the soil organic carbon (SOC) on fully vegetated sites with well-developed and deep mineral soil profile (Bjarnadóttir 2009). The age of the oldest afforestation sites examined were 50 years so increase of carbon in mineral soil can be confirmed up to that age. The conversion period for afforestation on Grassland soil is accordingly changed to 50 years instead of 20 years used in last year's submission (see also Chapter 7.12.1.3). Conversion period for land use changes to "Forest land" from "Other land" is changed comparatively. The area of cultivated forest in 2008 is estimated in NNFI as 34.38 kha (±1.64 kha 95% CL) whereof; 29.10 kha (±1.68 kha 95% CL) are Afforestation 1-50 years old on "Grassland converted to Forest land", 3.88 kha (±0.85 kha 95% CL) are Afforestation 1-50 years old on "Other Land converted to Forest land", 0.98 kha (±0.44 kha 95% CL) are Plantations in natural birch forests and 0.42 (±0.29 kha 95% CL) are Afforestation older than 50 years.

The total area of Forest land other than "Natural birch forest" is revised on basis of new data obtained in NNFI. In 2009 submission this area was estimated 29.61 kha (±1.83 kha 95% CL) in 2007 but in this year's submission the estimate for 2007 is 32.36 kha (±1.67 kha 95% CL) reflecting the effect of the recalculation.

The area of Forest land on organic soil is also revised according to new data from NNFI. The area of organic soil was for the inventory year 2007 reported 3.75 kha (±0.96 kha 95% CL) in 2009 submission but is estimated 2.53 kha (±0.70 kha 95% CL) for 2007 in this year's submission reflecting the recalculation.

CO_2 removal to living biomass in Afforestation 1-50 years old is recognised as level key source/sink in LULUCF considering subcategories resolution as reported. Land converted to Forest land is recognised as key source/sink considering only main land use categories. In last year's submission Forest land remaining forest land was recognized as such, but not in this year's submission reflecting longer conversion period applied.

The area of Forest Land used in the CRF is based on the NNFI. As mentioned before maps provided by IFR shows larger area of cultivated forests and less area of natural birch forests (natural birch woodland reaching >2 m in height) than the NNFI estimate. Cultivated forest cover map is built on an aggregation of maps used in forest management plans and reports. This result highlights the overestimation of the area of cultivated forest on these maps (Traustason and Snorrason 2008). The less area of Natural birch forest on maps is explained by the inclusion of young woodland which currently falls below 2 m height, but *in situ* is estimated to reach the 2 m threshold in mature state. The correction of mapped area of other categories due to these inconsistencies is explained in chapter 7.5.

7.12.1 **Carbon stock changes (5A)**

Calculation of the C-stock change for the natural birch forest from the data of NNFI has not yet been carried out so these figures are not estimated in this submission. Total woody C-stock of the natural birch woodland was estimated at 1300 kt C with average of 11 t C ha^{-1} from data sampled in an inventory conducted in 1987-1991 (Sigurðsson and Snorrason 2000). Taken into account the changes in area estimate the IFR new estimate of the woody C-stock of natural birch forest will change this figure drastically.

7.12.1.1 Carbon stock changes in living biomass

Carbon stock gain in the living biomass of trees is estimated based on data from direct field measurement in the NNFI. The figures provided by IFR are based on the inventory data from the first national forest inventory which was finished in 2009. The year 2009 was the last year of five in the first round of the national forest inventory (Snorrason 2010a; Snorrason in prep). Carbon stock losses in the living woody biomass is estimated based on data on activity statistics of commercial round-wood and wood-products production from domestic thinning of cultivated forest (Gunnarsson 2009). Data of wood from thinning of natural birch forest are omitted because the carbon gain in the natural birch forest is still not calculated and accounted for in this year submission.

Most of the cultivated forests in Iceland are relatively young, only 20% of it is older than 20 years, and clear cutting has not started. Thinning is taking place in some of the oldest forests and accounted for as losses in C-stock in living biomass for the first time as described above.

In the already mentioned ICEWOODS research project, the carbon stock in other vegetation than trees did show very low increase 50 years after afforestation by the most used tree species, Siberian larch, although the variation inside this period was considerable (Sigurdsson et al. 2005). The change in this stock was not estimated in the present submission but calculations built on research results will be applied in the next submission. Carbon stock samples of other vegetation than trees are collected on field plots under the field measurement in NNFI. Estimate of carbon stock changes in other vegetation than trees will be available from NNFI data when sampling plots will be revisited in the next five years.

7.12.1.2 Net carbon stock changes in dead organic matter

At the moment estimate of changes in dead organic matter is not estimated. Tier 1 (AFOLU Guidelines) default assumes no changes in dead wood or litter. New calculations built on research results will be applied in the next submission. As the sampling plots of the NNFI will be revisited in coming years, new data on changes in dead organic matter will be available.

7.12.1.3 Net carbon stock change in soils

In this year's submission drained forest organic soil is only reported in the category "Grassland converted to Forest Land- Afforestation 1-50 years' old" The estimated area is 8.7% of the category total area based on NNFI data and has been revised from last submission according to new data from the national forest inventory. The estimate applied in last year's submission was that 11.4% of all forest is grown on former wetlands and drained wetlands. In the process of adjusting the IGLUD map area to the reported area of forest the overlap of mapped forest land with other mapped categories was tested including the maps of drained areas. The overlap of cultivated forests with drained land was 18.25%. These variable estimates show the uncertainty of these estimates. The natural birch forest and the remaining afforested areas are mostly situated on mineral soils which can be highly variable regarding carbon content. Research results do show increase of carbon of soil organic matter (C-SOM) in mineral soils (0.3-0.9 t C $ha^{-1}yr^{-1}$) due to afforestation (Snorrason et al. 2003; Sigurðsson et al. 2008), and in a recent study of the ICEWOODS data a significant increase in SOC was found in the uppermost 10 cm layer of the soil (Bjarnadóttir 2009). The average increase in soil carbon detected was 134 g CO_2 m^{-2} $year^{-1}$ for the three most used tree species. This rate of C-sequestration to soil was applied to estimate changes in soil carbon stock in mineral soils at afforested sites 1-50 years old. Measurements of carbon stock changes in soil on revegetated and afforested areas are currently sparse but work is currently in progress that is expected to increase our understanding in that field. A comparison of 16 years old plantation on poorly vegetated area to a similar open land gave e.g. an annual increase of 330 g CO_2 m^{-2} $year^{-1}$ in SOM (Snorrason et al. 2003). For the mineral soil of Other land converted to Forest land same removal factor is used as for revegetation on devegetated soil, 0.675 Mg C ha^{-1} yr^{-1}.

7.12.2 **Other emissions (5(I), 5 (II), 5(III))**

Direct N_2O emission from use of N fertilisers is reported for Land converted to Forest Land since fertilisation is usually only done at planting. Fertilization on Forest Land remaining Forest Land is not occurring. The reported use of N fertilizers is based on data collected by IFR from the actors in Icelandic forestry. N_2O emissions from drainage of organic soils are also reported separately for forest land.

7.12.3 Land converted to forest land.

The AFOLU Guidelines define land use conversion period as the time until the soil carbon under the new land use reaches a stable level. Land converted to forest land is reported as converted from the land use categories “Other land” and from “Grassland”. Organic soil is only reported under land converted from Grassland-Afforestation 1-50 years old. Organic soils are not found in the land use category “Other land” and were not detected in the NNFI for afforestation before 1960. Accordingly organic soils are reported as not occurring.

7.12.4 Methodological issues

The methodology for NNFI is based on systematic sampling consisting of a total amount of nearly 1000 permanent plots. One fifth of the plots are measured each year and measurements are repeated at 5 year intervals for the cultivated forest and at ten years interval for the natural birch forest. The sample is used to estimate both the division of area to subcategories and C-stock changes over time (Snorrason and Kjartansson. 2004; Snorrason 2010a). Preparation of this work started in 2001 and the measurement of field plots started in 2005. The first forest inventory was finished in 2009 and in 2010 the second one will start with re-measurements of the plots measured in cultivated forest in 2005 together with new plots on afforested land since 2005. The figures provided by IFR are based on the inventory data of the first forest inventory (Snorrason in prep).

The area of both natural birch forests and cultivated forest are estimated from output of the systematic sampling of NNFI. The sample population for the natural birch forest is the mapped area of natural birch woodland in earlier inventories. The sample population of cultivated forest is an aggregation of maps of forest management plans and reports from actors in forestry in Iceland. In some cases the NFI staff does mapping in field of left out private cultivated forest. To ensure that forest areas are not outside the population area the populations for both strata are increased with buffering of mapped border. Current buffering is 16 m in cultivated forest but 24 m in natural birch forest. More detailed description of the methodology will be given by Snorrason (in prep).

The area of natural birch forest is assumed to be unchanged since 1990. Historical area of cultivated forest is estimated by the age distribution of the forest in the sample. The changes in the C-stock of cultivated forest for other years than 2008 are built on a tree species specific growth model but are calibrated towards the inventory results of 2008.

7.12.5 Emission/removal factors

Tier 3 is used to estimate the carbon stock change in living biomass of the trees in cultivated forest through the data from NNFI (Snorrason in prep). Emission from wood removals caused by thinning or clear cutting in the cultivated forest are now included. Currently they have minor importance as the mean age of plantation forest is low. Clear cuttings are not yet practiced but thinning is an increasing activity.

The losses reported in living biomass removed as wood are estimated by Tier 3 on basis of activity data of annual wood utilization from cultivated forest (Gunnarsson 2009).

No deforestation is reported for the inventory year. No recalculations are made of the deforestation reported in last submission. A special inventory of deforestation was conducted by IFR in 2008 to map deforested area and measure carbon stock changes in the years 1990-2007. Estimated deforested area and carbon stock changes for that period are built on that special inventory. Since then no deforestation has been reported to IFR.

As mentioned before carbon stock changes in living biomass in the natural birch forest are reported as not estimated.

Carbon stock change in living biomass in other vegetation than trees is not estimated at current state.

Tier 2, country specific factors are used to estimate annual increase in carbon stock in mineral soil. The removal factor (0.365 Mg C ha^{-1} yr^{-1}) for the mineral soil of the Grassland conversion is taken from the already mentioned study of Bjarnadóttir (2009). For the mineral soil of Other land converted to Forest land the same removal factor is used as for revegetation on devegetated soil, 0.675 Mg C ha^{-1} yr^{-1}. Revegetation and afforestation on devegetated soil are very similar processes, except that in the latter includes tree-planting.

Tier 1 and default EF = 0.16 [t C ha^{-1} yr^{-1}] (AFOLU Guidelines Table 4.6.) is used to estimate net carbon stock change in forest organic soils. For direct N_2O emission from N fertilization and N_2O emissions from drained organic soils, Tier 1 and default EF=1.25% [kg N_2O-N/kg N input] (GPG2000) and EF=0.6 [kg N_2O-N $ha^{-1}yr^{-1}$] (AFOLU Guidelines Table 11.1.) were used respectively.

7.12.6 Uncertainties and QA/QC

The estimate of C-stock in living biomass of the trees is based on results from the new national forest inventory of IFR. The C-stock changes estimated through the forest inventory fit well with these earlier measurements in research project (Snorrason et al. 2003; Sigurðsson et al. 2008).

The NNFI and the special inventory of deforestation have greatly improved the quality of the carbon stock change estimates although some sources are still not included (i.e. other vegetation than trees, dead wood and litter). Because of the design of the NNFI it is possible to estimate realistic uncertainties by calculating statistical error of the estimates. Error estimate for all data sources and calculation processes have currently not been conducted but are planned in the nearest future.

For the moment, error estimates are only available for the area of both natural birch forest and cultivated forest.

The IFR estimates the statistical error for total area of cultivated forest to be ± 1.64 kha (95% confidence limits). Error estimates for the area of Forest land subcategories are shown in the beginning of the Forest land chapter.

7.12.7 **Recalculations**

As described above the emission/removal estimate for forest land has been revised from previous submissions. The C-stock changes are based on direct stock measurements (Tier 3) as in last year's submission but reviewed on basis of additional data obtained since then. The restructuring of the data, due to changed conversion period, is implemented for the emission/removal estimate of all years prior to the inventory year. The estimate of changes in soil carbon in mineral soils in Afforestation 1-50 years old has great effects on the reported emission/removal. As result of this recalculation the total reported removal has increased from -80.04 Gg CO_2 eq for the year 2007 as reported in 2009 submission to -122.47 Gg CO_2 eq in this year's submission or a 53 % increase in removal. Last year's submission showed 46% reduction in reported removal for the year 2006. These fluctuations in reported emission removal of the category reflect the development in data availability and methodology applied for estimating this category.

7.12.8 **Planned improvements regarding Forest Land**

Data from NNFI are used for second time to estimate main sources of carbon stock changes in the cultivated forest. In next year it is planned to add carbon stock change estimate in natural birch forest for the first time together with estimates of carbon stock changes in other vegetation than trees, litter and dead-wood.

Sampling of soil, litter, and other vegetation than trees, is included as part of NNFI and higher tier estimates of changes in the carbon stock in soil, dead organic material and other vegetation than trees is expected in future reporting when data from re-measurement of the permanent sample plot will be available.

It is planned to improve estimates on area and stock changes of deforestation and reduction of living carbon stock due to wood removals in the national forests inventory. Also, a new mapping of the natural birch woodlands will start next summer. That will *inter alia* make it possible to detect natural afforestation. One can therefore expect gradually improved estimates of carbon stock and carbon stock changes in forest in Iceland. As mentioned before improvements in forest inventories will also improve uncertainty estimates both on area and stock changes.

7.13 **Cropland**

Cropland in Iceland consists mainly of cultivated hayfields, many of which are on drained organic soil. A still negligible but increasing part is used for cultivation of barley. Cultivation of potatoes and vegetables also takes place.

Mapping of cropland based on satellite images and support of aerial photographs has been included in the construction of IGLUD. Previous mapping of Cropland was revised in 2009 by AUI through on screen digitations. The total area of Cropland in IGLUD, taking into account the order of compilation applied, is estimated 169.23 kha and reported in CRF.

The area of drained soils within Cropland was estimated separately on basis of a density study on the ditches network (Gísladóttir et al. 2009). All Cropland area where the ditches density was more than 10 km ditches km^{-2} was estimated as drained cropland. This estimate is 55.11 kha and is reported as wetland converted to Cropland.

No information is available on emission/removal regarding different cultivation types and subdivision of areas according to types of crops cultivated is not attempted. Cropland remaining Cropland is identified as a key area in applicable land use categories (Table 7.12).

7.13.1 **Carbon stock changes (5B)**

7.13.1.1 Carbon stock changes in living biomass

As no perennial woody crops are cultivated in Iceland, no biomass changes need to be reported. Shelterbelts, not reaching the definitions of forest land, do occur but are not common. This might be considered as cropland woody biomass. No attempt is made to estimate the carbon stock change in this biomass. For the land converted to Cropland only wetland converted to Cropland is estimated. Most of that conversion is assumed to have taken place several decades ago (i.e. prior to 1990), but no time series are available on that conversion. Changes in living biomass in connection with conversion of land to Cropland are, according to Tier 1 method, assumed to occur only at the year of conversion as all biomass is cleared and assumed to be zero immediately after conversion. No data is available for conversion of land to Cropland in the inventory year as no time series exist for the categories involved. Some data exist on the amount of woody and other above ground biomass in wetlands which could be applied to estimate the loss in this category provided the area estimate is available. According to this data, (Grétarsdóttir and Guðmundsson 2007), living above ground biomass in wetlands is 1.8 t dw ha^{-1} or 0.9 t C ha^{-1} assuming 0.5 t C tdw^{-1} biomass. This factor is therefore recognized as possible sink/source in the first year of conversion.

7.13.1.2 Net carbon stock changes in dead organic matter

The AFOULU Guidelines Tier 1 methodology assumes no or insignificant changes in dead organic matter (DOM) in cropland remaining cropland and no emission /removal factors or activity data needed. No data is available to estimate the possible changes in dead organic matter in remaining cropland. The majority of land classified as cropland in Iceland is hayfields with perennial grasses only ploughed or harrowed at decade intervals. A turf layer is formed and depending on the soil horizon definition it can be considered as dead organic matter. This is therefore recognised as a possible sink/source although no data is available. The only reported conversion of land to Cropland is Wetland converted to Cropland. Changes in DOM in the year of conversion are recognized as possible source, but no information is available on the area converted in the inventory year and no time series for individual years or periods back to 1990. As for carbon stock in living biomass on wetlands, some data exist to estimate changes in this factor (Grétarsdóttir and Guðmundsson 2007). According to this data dead organic matter of wetland is estimated as 1.3 t dw ha^{-1} or 0.7 t C ha^{-1}.

7.13.1.3 Net carbon stock change in soils

Net carbon stock changes in mineral cropland soil are not estimated. No data is available and no default relative stock change factors recognised as applicable to perennial hayfield.

Emissions from drained organic cropland soils are reported separately for the first time in this year's submission. The area of drained cropland is estimated from IGLUD as described above. Of the area estimated drained, 98% is assumed to be on organic soil according to AUI unpublished data. Carbon dioxide emission from the category Wetland converted to Cropland- organic soil is recognized as key source/sink Table 7.8.

7.13.2 Other emissions (5(I), 5 (II), 5(III), 5(IV))

Direct N_2O emission from use of N fertilisers is included under emissions from agricultural soils.

N_2O emissions from drainage of organic soils are reported under the Agriculture sector 4.D.1.5- Cultivation of Histosols.

Carbon dioxide emissions from agricultural lime application are estimated. Information on lime application is obtained from distributors. Numbers reported included lime application in the form of shell-sand, which contains 90 % $CaCO_3$, dolomite and limestone. Limestone or other calcifying agents included in many of the imported fertilizers are also included. Although the ratio of calcifying materials is low in these fertilizers the amount of fertilizers applied make this source relatively large. Numbers on lime application are only available at the national level and all of it is assumed to be applied on cropland.

7.13.3 Land converted to Cropland

The conversion period for Wetland converted to Cropland has not been analyzed. Most of the drainage of wetlands was carried out in 1940-1990 (Figure 7.7). Drained hayfields maintain higher SOC than hayfields on mineral soil for very long period (decades) (AUI unpublished data). Until the length of conversion period has been established it is assumed that all drained cropland is still under conversion and reported as such.

Wetland converted to Cropland is recognized as key source/sink for LULUCF considering all subcategories reported Table 7.8 and Land converted to Cropland is recognized as key source/sink in LULUCF considering only main land use categories Table 7.9.

7.13.4 **Emission factors**

The CO_2 emission from Wetland converted to Cropland due to changes in soil carbon are calculated according to Tier 1 methodology using the EF= 5.0 tC $ha^{-1}yr^{-1}$ (AFOLU Guidelines Table 5.6).

The CO_2 emission due to liming of cropland is calculated by conversion of carbonated carbon to CO_2.

7.13.5 **Uncertainty and QA/QC**

The area of cultivated land in the inventory year land is 129 kha according to agricultural statistics from Farmers Association of Iceland compared to currently 169 kha reported. The area of Cropland is in this year's submission for the first time based on IGLUD maps. On those maps no separation of abandoned cropland and cropland still under cultivation is attempted. Some of the mapped area is accordingly likely to be abandoned cropland. The area of cultivated land in 1994 was 146 kha according to agricultural statistics indicating an area of 17 kha as abandoned or converted to other land use. The emissions reported from Cropland are based on two factors i.e. CO_2 emissions due to drainage of organic soil calculated on basis of drained area, and emissions due to liming calculated on basis of amounts of liming agents and independent of area applied on. The emissions due to drainage are not considered to depend on the type of cultivation or abandonment of cropland. The mapping in IGLUD has been controlled through systematic sampling where land use is recorded in the sampling points. Preliminary results indicate that 91% of land mapped as Cropland is cropland and that 80% land identified *in situ* as cropland is currently mapped in IGLUD as such (AUI unpublished data).

The area of drained cropland is estimated from geographic analysis of the ditches network as described above. Applying the same method as for drained grassland to estimate the drained soils of cropland, results in a much larger area estimated as drained. Drainage of hayfields and other cropland is generally much more intense than drainage of grassland, as drained cropland needs to withstand the use of heavy machines. Density of ditches is accordingly usually higher within cropland than in Grassland. The EF used for drained Cropland is also larger the for drained Grassland partly reflecting difference in drainage.

No quality control or quality assurance has been undertaken regarding the submitted amounts of liming agents. The change in C-stock in mineral Cropland soils is not estimated. These changes are likely to be in both directions depending on management regimes. The quantity of uncertainty for cropland emissions/removals is not estimated.

7.13.6 **Planned improvements regarding Cropland**

The use of IGLUD maps to estimate the area of Cropland and its subdivision to drained cropland and other croplands is an important step in improving the emission/removal estimate of the category. Further improvements of the mapping and subdivision are planned for next year, including field controlling of mapping, division to soil classes and cultivated crops.

Considering that the emissions from drained cropland are recognized as key source, it is important to move to a higher tier in estimating that factor. Establishing country specific emission factors, including variability in soil classes is already included in ongoing research projects at AUI. These studies are assumed to contribute to the new emission factors. Data, obtained through fertilization experiments, on carbon content of cultivated soils is available at AUI. The data is currently being processed and is expected to yield information on changes in carbon content of cultivated soils over time.

7.14 **Grassland**

Grassland is the largest land use category identified by present land use mapping as described above. The Grassland category is very diverse with regard to vegetation, soil type, erosion and management.

The land included under the Grassland category is subdivided into three subcategories i.e. “Grassland remaining Grassland”, “Wetland converted to Grassland” and “Other land converted to Grassland” (revegetation).

7.14.1 **Grasslands remaining grassland**

The category Grassland remaining Grassland includes all land where vascular plant cover is 20% or more as compiled from IGLUD. This land is e.g. heath-lands with dwarf shrubs, small bushes, grasses and mosses in variable combinations, fertile grasslands, and partly vegetated land.

Large areas in Iceland suffer from severe degradation where the vegetation cover is severely damaged or absent and the soil is partly eroded but the remaining Andic soil still has high amounts of carbon. Resent research indicates that the carbon budget of such areas might be negative, resulting in CO_2 emission to the atmosphere (AUI unpublished data). The vegetation cover in many other Grassland areas in Iceland is at present increasing both in vigour and continuity (Náttúrufræðistofnun_Íslands 2005). In these areas, the annual carbon budget might be positive at present with C being sequestered from the atmosphere. Whether these changes in vegetation are related to changes in climate, management or a combination of both is not clear. The subdivision of Grassland, according to land degradation, was not implemented in this year’s submission, but is one of the IGLUD objectives as described in Guðmundsson et al (2010). Subdivision based on management regimes, i.e. unmanaged and managed and the latter further according to grazing intensity is pending but not implemented.

7.14.2 **Drained areas**

Extensive drainage of wetland took place in Iceland mostly in the period 1940-1985 (Figure 7.7). This drainage was aided by governmental subsidies. Only a minor portion of these drained areas was turned to hayfields or cultivated, the larger part of the lowland wetlands in Iceland were converted to Grassland or Cropland through this drainage effort. The governmental subsides involved official recording of the drainage, kept by the Farmers Association. The subsidies of new drainage ended in 1987 (Gísladóttir et al. 2007). Since then, the recording of drainage has been limited, and no official recording is presently available. All ditches recognizable on satellite images (SPOT 5) have recently been digitized in cooperative effort of AUI and NLSI (Figure 7.5).

A second subcategory reported is Wetland converted to Grassland. The area of this category is for the first time estimated on the basis of IGLUD mapping in this year's submission. Before compilation to the IGLUD map, the map layer of "drained land" was prepared as following: All ditches in the AUI/NLSI map of ditches were covered with a buffer zone of 200 m to each direction. The resulting area was then tailored according to other existing map layers and geographical information to exclude areas not likely to have been wet before or to have been drained. From the buffer zone the area mapped as "Partly vegetated land", "Sparsely vegetated land" and "Shrubs and natural birch forest" were excluded as these land covers are not generally wet. All land with slope exceeding 10° was excluded for the same reason. Land presently mapped as lakes and rivers and the area extending beyond seashore cost line were excluded as they have obviously not been drained.

This map layer was then compiled into the IGLUD map according to the order of compilation listed in Table 7.2 thereby excluding all higher ranking map layers. Due to the order of compilation; all Settlement, Forest Land, Cropland areas were excluded as well as Reservoirs and Glaciers and perpetual snows. The map layers of "Wetland", "Semi-wetland" and "Semi-wetland/wetland complex" from the Farmland database (NYTJALAND) are not excluded from the map layer of drained land, neither in the process of preparing the map of drained land nor in the compilation process in to IGLUD. The identification of these land cover classes in the Farmland database is based on the signature on satellite images of areas classified according to vegetation more than wetness. The wetland vegetation can dominate in these areas for long time after drainage if no other disturbances occur. Most of the land classified as drained grassland has not been ploughed or harrowed and wetland vegetation is still prevailing in many areas. There is therefore large uncertainty regarding these areas and the exclusion of that land as whole from the map layer drained land not considered justifiable.

In previous submissions the total area of land drained was calculated from the total length of ditches as recognised on the map of digitized ditches. A conversion factor of 7.3 km ditches km^{-2} (Óskarsson 1998) was applied. Total length of mapped ditches is 27,240 km. By applying the conversion factor, the total estimated area of drained land was estimated 374.8 kha previously compared to 502.9 kha identified as drained land, as described above, before compilation into IGLUD.

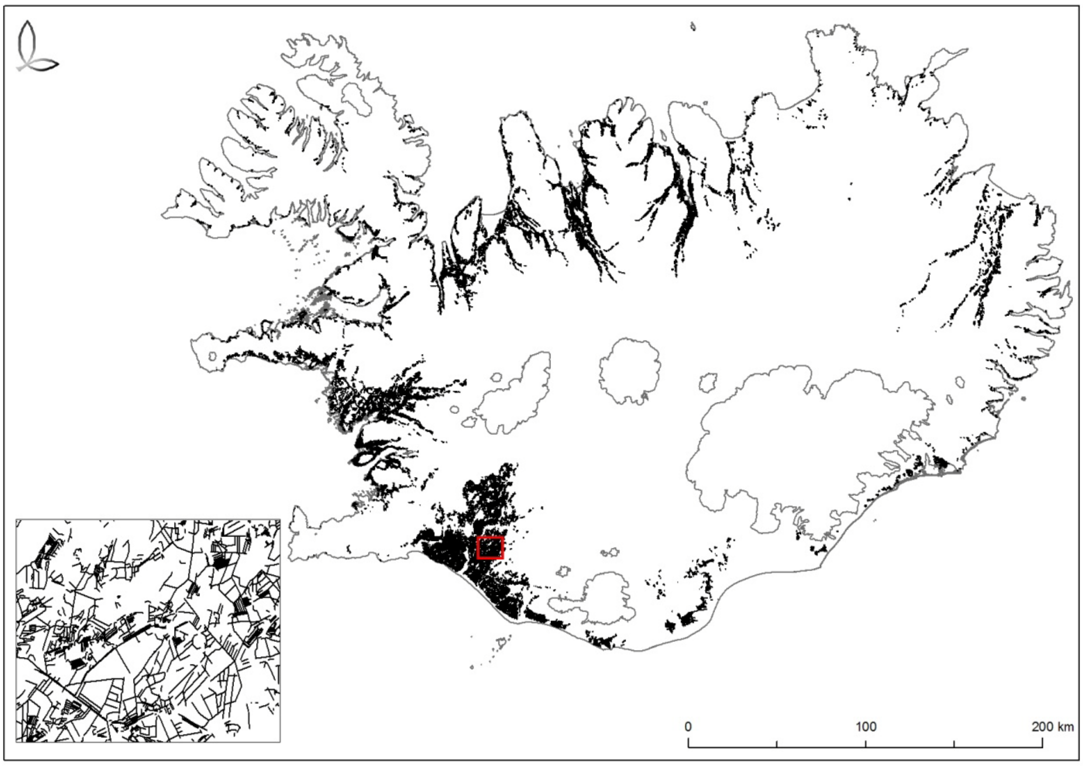

Figure 7.5 Map of Iceland showing all digitized ditches. (AUI 2008)

7.14.3 **Revegetation**

The third subcategory reported is “Other land converted to Grassland”. This land use conversion is the result of revegetation activity. For the vast majority of land, according to SCSI, where revegetation is started the original vegetation cover is less than 20%. Accordingly, this land does not meet the definition of Grasslands.

Since the settlement of Iceland large areas of the former vegetated areas have been severely eroded and in large areas the entire soil mantle has been lost. It has been estimated that a total of 60-250×10^3 kt C has been oxidized and released into the atmosphere in the past millennium (Óskarsson et al. 2004). The estimated current ongoing loss of SOC due to erosion is 50-100 kt C yr^{-1} according to the same study. No attempt is made to include that estimate in the CRF. The revegetation of deserted areas sequesters some of the carbon back into vegetation and soil.

The SCSI was established in 1907. Its main purpose was, and still is, the prevention of ongoing land degradation and erosion, the revegetation of eroded areas, restoration of lost ecosystem and to ensure sustainable grazing land use. The reclamation work until 1990 was mostly confined to 170 enclosures, covering approximately 3% of the total land area. The exclusion of grazing animals from the reclamation areas, and other means of improving livestock land use, is estimated to have resulted in autogenic soil carbon sequestration, but the quantities remain to be determined. Record keeping of soil conservation and revegetation efforts until 1960 was limited. From 1958 to 1990, most of the activities involved spreading of seeds and/or fertilizer by airplanes and direct seeding of lymegrass (*Leymus arenarius* L.) and other graminoids. These activities are recorded to a large extent. The emphasis on aerial distribution has decreased since 1990 as other methods have proven more efficient, such as increased participation and cooperation with farmers and other groups interested in land reclamation work. Methods for recording activities have been improved at the same time, most noticeably by using aerial photographs and GPS-positioning systems. Since 2002, GPS tracking has increasingly been used to record activities as they occur, e.g. spreading of seeds and/or fertilizer. In 2008 almost all activities were recorded simultaneously with GPS-units (Halldórsson et al. 2010).

The area of land being revegetated is divided into two subcategories, based on when the activity started i.e. “Land revegetated before 1990” and “Land revegetated since 1990”. The latter category represents activity accountable as Kyoto Protocol commitments. This subdivision also reflects difference in methods used for area estimate prior to 1990 and hence their uncertainty.

The SCSI now keeps a national inventory on revegetation areas since 1990 based on best available data. The detailed description of methods will be published elsewhere (Halldórsson et al 2010 in prep). The objectives of this inventory are to monitor the changes in C-stocks, control and improve the existing mapping and gather data to improve current methodology. Activities which started prior to 1990 are not included in this inventory at present. The National Inventory on Revegetation Area (NIRA) is based on systematic sampling on predefined grid points in the same grid as is used by the Icelandic Forestry Service (IFS) for NNFI (Snorrason and Kjartansson. 2004) and in IGLUD field sampling. The basic unit of this grid as applied by SCSI and IFS is a rectangular, 1.0 x 1.0 km in size. A subset of approximately 1000 grid points that fall within the land mapped as revegetation since 1990 was selected randomly and will be visited. Points found to fall within areas where fertilizer, seeds, or other land reclamation efforts have been applied, will be used to set up permanent monitoring and sampling plots. Each plot is 10×10 m. Within each plot, five 0.5×0.5 m randomly selected subplots will be used for soil and vegetation sampling for C-stock estimation.

Data already available in NIRA has already led to reduced estimation of revegetated land since 1990. Areas revegetated before 1990 have also been adjusted proportionally, resulting in decreased area. Current estimate for total area revegetated areas prior to 1990 is 98.81 kha and 100.65 kha for areas since to 1990. Revised estimate on EF is not yet available.

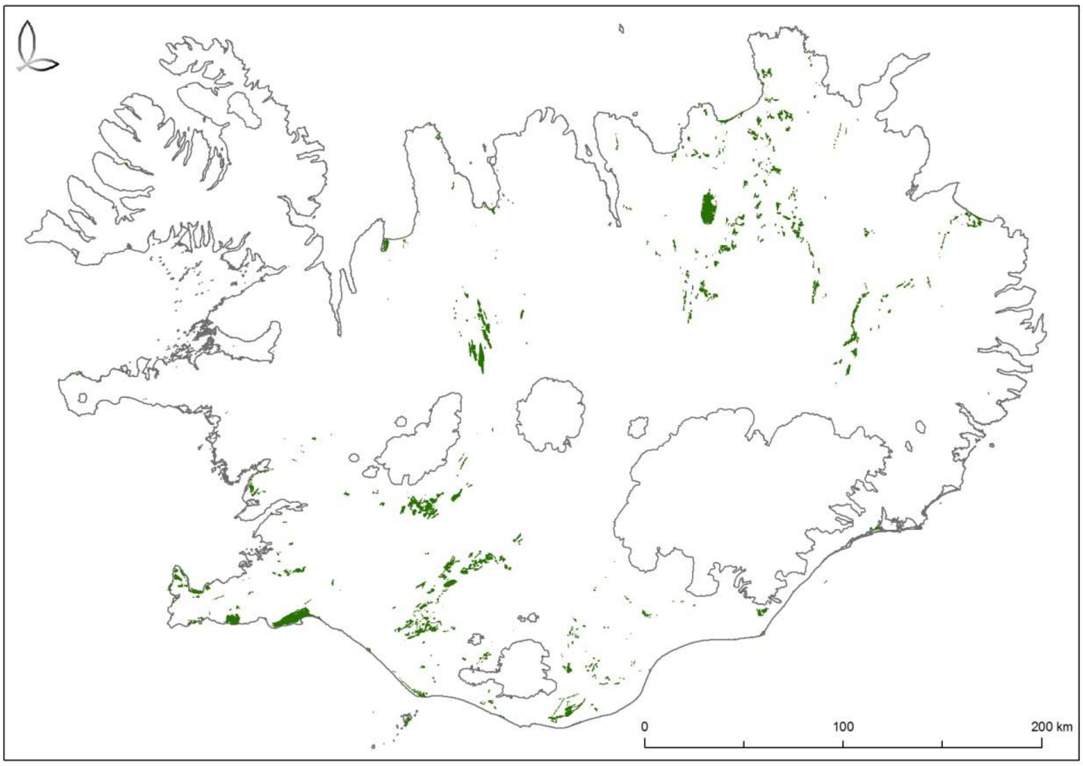

Figure 7.6 Map showing revegetation areas (green) established during 1990-2008. (Halldorsson et al. in prep)

7.14.4 Category key factors

Of six LULUCF categories recognized as key source/sink, considering subcategories as reported, four are Grassland categories i.e. (1) Wetland converted to Grassland – Organic soil CO_2, (2) Wetland converted to Grassland – Organic soil N_2O, (3) Other land converted to Grassland- Revegetation since 1990-Mineral soil, and (4) Other land converted to Grassland- Revegetation before 1990-Mineral soil (Table 7.8). Considering only main land use categories (Table 7.9) Land converted to Grassland is the largest source/sink component with 65% of CO_2 equivalent absolute values in LULUCF. Both the categories Grassland remaining Grassland and Land converted to Grassland are recognised as key land use category considering area of main land use categories (Table 7.11). Considering area of land use categories at highest resolution reported (Table 7.10) both the categories Grassland remaining Grassland and Wetland converted to Grassland- Organic soil are recognized as key area and of the categories classified as applicable toward emission removal contribution (Table 7.12) both subcategories of "Other land converted to Grassland" i.e. Revegetation before and since 1990 are added as key area.

7.14.5 Carbon stock changes (5C)

Carbon stock changes are estimated for both subcategories included under Land converted to Grassland. The C-stock changes of Grassland remaining Grassland are not estimated in present submission.

The emissions from all drained organic soils except those of Forest land has in previous submissions been reported as aggregated number. In this year's submission the area is for the first time disaggregated and emissions reported separately under Grassland and Cropland.

7.14.5.1 Carbon stock changes in living biomass

No information is presently available on overall changes in living biomass of Grassland remaining Grassland although it is known that changes are occurring (Magnússon et al. 2006). Carbon stock changes in living biomass on drained land are possible e.g. due to invasion of shrubs, changes in grazing pressure or increased nutrient availability due to mineralization as SOC decomposes.

Changes in carbon stock in living biomass in Grassland remaining Grassland or Wetland converted to Grassland are not estimated, as is consistent with the Tier 1 methodology for the Grassland remaining Grassland. No data is presently available for changes in living biomass in Wetlands converted to Grassland.

Carbon stock changes in living biomass are estimated for the category Other land converted to Grassland (Revegetation). The stock changes in living biomass reflect the increase in vegetation coverage and biomass achieved through revegetation activities. The changes in biomass are estimated as relative contribution (10%) of total C-stock increase as estimated in research project aimed at estimating rate of carbon sequestration due to revegetation (Aradóttir et al. 2000; Arnalds et al. 2000). The carbon stock in living biomass is estimated to have increased by 7.41 Gg C and 7.55 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 27.17 Gg CO_2 and 27.67 Gg CO_2 from the atmosphere, respectively.

7.14.5.2 Net carbon stock changes in dead organic matter

Tier 1 methodology of AFOLU Guidelines assumes no changes in dead organic matter in Grassland remaining Grassland and changes reported as not applicable. For land converted to grassland, Tier 1 assumes the stock changes to take place in 1st year of conversion. Most of the drainages included in category Wetland converted to Grassland are older than from 1985 (Fig. 7.7). No data is available on Wetland converted to Grassland the inventory year. Changes in dead organic matter are thus not requested by the AFOLU Guidelines. Tier 1 methodology for conversions older than one year and the information needed to move up to higher tiers for the category Wetland converted to Grassland is at present not available for this stock. The changes in dead organic matter are included in C-stock changes in living biomass for the category "Other land converted to Grassland" (Aradóttir et al. 2000).

7.14.5.3 Net carbon stock change in soils

Changes in carbon stock in mineral soils of land under categories Grassland remaining Grassland or Wetland converted to Grassland are not estimated due to lack of data. Tier 1 methodology gives by default no changes if land use, management and input (F_{LU}, F_{MG}, F_I) are unchanged over a period. Information needed to move up to higher tiers for these land use categories is at present not available.

For the category Other land converted to Grassland (Revegetation) the changes in carbon stock in mineral soils are estimated applying Tier 2 and CS emission (/removal) factor. The carbon stock in mineral soils is estimated to have increased by 66.69 Gg C and 67.94 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 244.54 Gg CO_2 and 249.10 Gg CO_2 from the atmosphere.

Carbon stock changes in mineral soil of land both under “Other land converted to Grassland- Revegetated before 1990” and “Other land converted to Grassland-Revegetated since 1990”is recognised as key source/sink in LULUCF considering categories as reported at highest resolution Table 7.8.

The carbon stock changes in organic soils of land under Wetland converted to Grassland are estimated applying Tier 2 methodology. Of the drained area 98% are assumed organic soil, based on AUI unpublished data. Three soil types; Histosol, Histic Andosol and Gleyic Andosol are included. The two organic soil types are Histic Andosol and Histosol. Although Gleyic Andosol is not classified as organic, it is included here. Organic soils in Iceland generally are with relatively low C/N ratio and are therefore considered nutrient rich. The carbon stock in drained organic soils is estimated to have decreased by 369.07 Gg C in the inventory year emitting 1,353.27 Gg CO_2. Thereby being the single largest source of GHG in LULUCF.

This factor is identified as level key source factor of LULUCF and as a key area both regarding reported area considering highest reported resolution and applicable area.

7.14.6 **Other emissions (5(IV))**

Liming of Grassland soil is not practiced and therefore reported as not occurring. Due to the structure of the CFR- Reporter software version 3.4.3, used in preparing the CRF tables, non-CO_2 emission resulting from drainage i.e. N_2O still needs to be reported under “5.G. Other”, where it is included as subdivision “*Wetland converted to Grassland Non-CO2 emission-5(II) Non- CO2 emission from drainage of soils and wetlands-Organic soils*” (see chapter7.18).

The N_2O emissions resulting from use of fertilizers in revegetation is likewise reported under “5.G. Other- Other emissions due to Revegetation activities- 5(I) Direct N2O emission from N fertilization of Forest land and Other” due to CRF-Reporter limitations.

7.14.7 **Emission factors**

The Soil Conservation Service of Iceland records the revegetation efforts conducted. A special governmental program to sequester carbon with revegetation and afforestation was initiated in 1998-2000 and has continued since then. A parallel research program focusing on carbon sequestration rate in revegetation areas was started the same time (Aradóttir et al. 2000; Arnalds et al. 2000).

No Tier 1 default emission/removal factors are available for Revegetation. The emission factor used for calculating emission/removal resulting from revegetation efforts are estimated as -0.75 kt C/kha/yr based on precautious estimates from data collected in 1998-2000 (Arnalds et al., 2000; Aradottir et al, 2000). Also, based on the same data the contribution of changes in carbon stock of living biomass (including dead organic matter) and soil were estimated as 10% and 90% respectively. All revegetated areas are assumed to accumulate carbon stock at the same rate in the present submission. The CS emission factors applied for C-stock changes in living biomass (including dead organic matter) and mineral soils of land under the category "Other land converted to Grassland "are -0.075 and -0.675 kt C/kha/yr respectively.

Emissions of CO_2 from organic soil in Wetland converted to Grassland are calculated according to Tier 2 methodology and uses the emission factor EF = 1.1 [t C ha-1 yr-1] (AFOLU Guidelines Table 7.4). In the "Report of the individual review of annual submission of Iceland submitted in 2009" (UNFCCC 2010) it is recommended that the emission factor used for C stock in organic soil under Grassland in 2009 submission is reconsidered. The default EF for Grassland is 0.25 tC ha^{-1} yr^{-1} (AFOLU table 6.3). That value is stated to be directly calculated from the EF of Cropland as one quarter of that value. The EF value for Cropland in Boreal/Cold Temperate climate is 5.0 tC ha^{-1} yr^{-1} (AFOLU table 5.6) and has been revised since GPG-LULUCF 2003. The EF for grassland organic soils was not raised comparatively although stated to be directly calculated from that factor. There is accordingly certain inconsistency in default EF's in AFOLU. In resent review paper on GHG emission from organic soils in Nordic countries Maljanen et al (Maljanen et al. 2010) report average emission of 1320 g CO2 m^{-2} yr^{-1} or 3.6 tC ha^{-1} yr^{-1} for abandoned croplands in Scandinavia. Óskarsson (1998a) estimated CO2 emission from drained peatlands in Iceland to be 2 tC $ha^{-1}yr^{-1}$. Preliminary results from other recent measurements in Iceland (Gudmundsson and Óskarsson 2010) indicate even higher emission. Compared to these results the applied EF is relatively low but more in line than the default EF for grassland according to AFOLU table 6.3. Therefore the method used is better described as Tier 2 than Tier 1 as was stated in previous submissions, as it involves country specific evaluation of emission factors applied. Considering the category being a key source it is urgent to increase the certainty of the EF used, as well as the accuracy of area estimate. EF for N_2O is discussed in chapter 7.18.2.2.

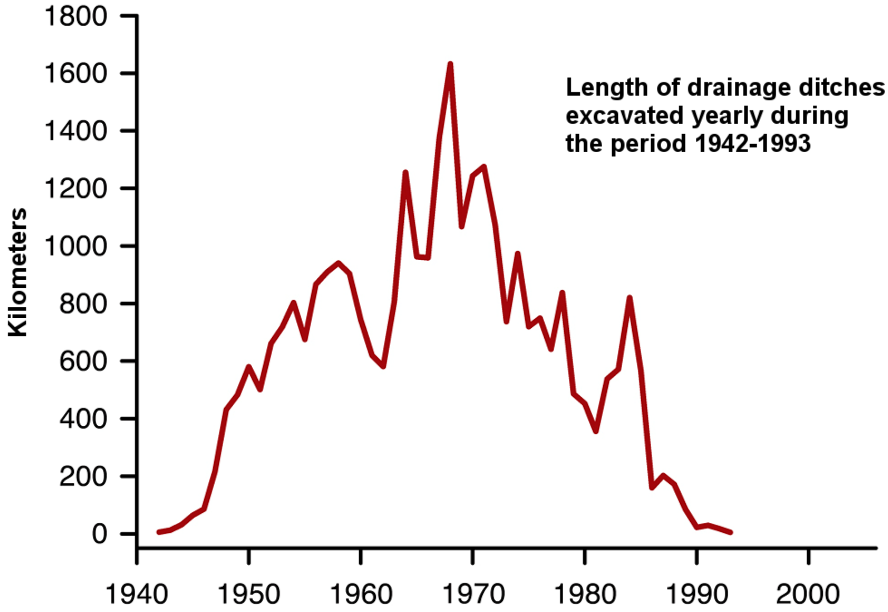

Figure 7.7 Length of ditches subsidised in 1942-1993 (Based on information from the Icelandic Farmers' Association)

7.14.8 **Land converted to Grassland.**

Two categories of land converted to grassland are reported in this year's submission, i.e. "Wetland converted to Grassland" and "Other land converted to Grassland".

The AFOLU criteria on length of transition period it lasts until the soil has reached stabile carbon level of the resulting land use category. The drained areas have generally not reached the same level of soil carbon as grassland mineral soils (AUI unpublished information). Length of transition period has not been determined, but all drained grassland is assumed to still remain in transition period. The excavation of ditches was mostly finished before 1990 according to subsided ditches (Figure 7.7). Since subsidies ended the centralized recording of drainage has not been maintained as before and numbers annual drainage is not available.

The revegetation activity involves establishing vegetation on eroded or desertified land or reinforcing existing vegetation. Most land hereto revegetated has involved establishing vegetation on land which has less than 20% cover of vascular plants according to SCSI and does therefore not meet the definitions of grassland (Halldórsson et al. 2010). The transition period for "Other land converted to Grassland" has not been determined but it will take decades to centuries to reach the C level of Brown Andosol (2-7%) at the rate of accumulation assumed in EF. All revegetated land is therefore reported as land still being converted to Grassland.

7.14.9 **Uncertainty and QA/QC**

Uncertainty in reported emission from this category is assumed to be large. Several components contribute to this uncertainty. The CO_2 emissions from mineral soils of Grassland remaining Grassland, which are not estimated. This is potentially a large source considering the severe erosion in large areas. These emissions might be counteracted by carbon sequestration in areas where vegetation is recovering from previous degradation.

Uncertainty in reported emissions from drained soil is also substantial. That uncertainty is both due to uncertainty in the estimate of the size of the drained area and in the uncertainty of EF's applied. The size of the drained area is for the first time in this year's submission estimated from IGLUD as described above. The accuracy of that mapping still needs to be tested through ground truthing. Many factors can potentially contribute to the uncertainty of the size of drained area. Among these is the quality of the map of ditches. Ongoing survey on the type of soil drained has already revealed that some features mapped as ditches are not ditches but e.g. tracks or fences. The ratio of these wrongly mapped ditches has not yet been determined. In other areas existing ditches have not been spotted on the images used for mapping in some areas. The width of the buffer zone, applied on the mapped ditches, is set to be 200 m to each side as determined from an analysis of the Farmland database (Gísladóttir et al. 2007). The validity of this number needs to be confirmed. The map layers used to exclude certain types of land cover from the drained areas are with their uncertainty which is transferred to the estimate on area of drained land. The decision to rank the map layers of wetland, semi-wetland and wetland/semi-wetland complex lower than drained land most certainly included some areas as drained although still wet.

It can be assumed that the area with drained soil decreases as time passes, simply because the drained soil decomposes and is "eaten" down to the lowered water level and thus become wet again. On the other hand the decomposition of the soil also results in sloping surface toward the ditch, which potentially increases runoff from the area and less water is available to maintain the water level. No attempt has been made to evaluate these effects of these factors on drained area.

Applying one EF for all drained land also involves many uncertainties. The emission can be supposed to vary according to age of drainage, e.g. due to changes in the quality of the soil organic matter, it can also vary according to depth of the drained soil and type of soil drained among other factors. This uncertainty has not been evaluated.

Calculation of removal/emission of carbon due to revegetation depends on the size of the area and the chosen emission/removal factor. The approach is 'Tier 1 (2)' approach based on a simple removal rate factor based on measurement of chrono-sequential accumulation of carbon on revegetated areas of known age. Both numbers have a large uncertainty.

The areas where revegetation is carried out vary considerably with regards to soil, climate and methods used. The success of revegetation efforts is also very variable and the same applies therefore to the rate of sequestration. Although some of the sources of this variability have been identified, it is far from being adequately explained (Arnalds et al. 1999; Arnalds et al. 2000; Arnalds et al. 2002).

The mapping method and registration of the revegetation in the first year of reporting (1998) was based on available records for each site and corresponding area estimates. The estimated hectares are based on amount of seeds and fertilizers used. This method may have introduced relatively large errors into the area estimates and may introduce risks of either double counting or excluding areas. The reported size of area subjected to revegetation since 1998 is increasingly based on simultaneous GPS recordings. The reported area in this submission is corrected according to preliminary results from the National Inventory of Revegetation (NIRA). Corrections and adjustments will be an ongoing effort in the coming years as information is gathered and knowledge accumulated.

Revegetated land area prior to 1990 is subject to larger uncertainties than area after that time. It is possible that some of these older areas need to be re-categorized.

Emission factors for both CO_2 and N_2O are stated with large uncertainty range in the AFOLU Guidelines.

7.14.10 Planned improvements regarding Grassland

Due to the potential importance of emissions, and removal in case of e.g. changed management, from/to mineral grassland soils, it is recognized as high priority issue to move up to a higher tier level with respect to estimates of carbon stock changes in soil for that subcategory.

Severely degraded soils are widespread in Iceland as a result of extensive erosion over a long period of time. Changes in mineral soil carbon stocks are a potentially large source of carbon emission. The importance of this source must be emphasized since Icelandic mineral grassland soils are almost always Andosols with high C content (Arnalds and Óskarsson 2009) Dividing the area of grassland remaining grassland into subcategories, based on management and by taking soil and vegetation degradation into account is currently under preparation as part of the IGLUD project.

Emissions of both CO_2 and N_2O from Wetland converted to Grasslands are identified as key sources for LULUCF. Improving the resolution of recorded land use, soil types and refinement of emission factors is highly important for this category. Improvements in ascertaining the extent of drained organic soils in total and within different land use categories and soil types is also a priority.

Improvements in both the sequestration rate estimates and area recording for revegetation, aim at establishing a transparent, verifiable inventory efforts accountable according to the Kyoto Protocol. Three main improvements are planned and currently being carried out in part. The first is the improvement in activity recording, including both location (area) and description of activities and management. This is already being actively implemented, as data on reclamation projects started after 1990 are currently under revision. This revision will be concluded by the end of 2010. Mapping of all activities since 1990 is verified by visiting points within the 1×1 km inventory grid. Recording of activities initiated before 1990 is also ongoing. The second improvement is pre-activity sampling to establish a zero-activity baseline for future comparisons of SOC. This will be implemented for all new areas established in 2010 and later (Halldórsson et al. 2010). The third improvement is the introduction of a sample based approach, combined with GIS mapping, to identify land being revegetated, and to improve emission/removal factors and quality control on different activity practices. The approach is designed to both confirm that area registered as subjected to revegetation efforts are correctly registered and to monitor changes in carbon stocks.

When implemented, these improvements will provide more accurate area and removal factor estimates for revegetation, subdivided according to management regime, regions and age.

7.14.11 **Recalculation**

Drained land has previously been reported as an aggregate number for all categories except forest land but is now reported separately for Grassland and Cropland. Also, the method applied to estimate the area drained differs from the one used in previous submissions. Due to these changes the emission reported from “Wetland converted to Grassland” is recalculated for the years 1990-2007.

7.15 Wetland

The reported emission for this category is structured as in last year’s submission. Flooded land is divided to “Land converted to wetland” and “Wetland remaining wetland”. There are no changes in the reported emission for the wetland category from last year’s submission as no new areas were flooded in the year 2008. The estimated area of the subcategory “other wetlands” is substantially smaller than reported in last year’s submission due to the different method applied. The category as reported is an aggregate of two defined subcategories i.e. (1) Mires and fens and (2) Semi-wet areas.

The mapping of drained land in IGLUD and ranking that map layer above the map layers summing up to the category other wetland most likely explains most of the changes in the area estimate. All drained land was assumed in previous submissions to be already included under the Grassland category.

Emission are only estimated for the categories Grassland and Other land converted to wetland resulting from flooding of land due to establishment of hydropower reservoirs.

7.15.1 **Carbon stock changes (5D)**

Areas of Wetland remaining wetlands are divided into three subcategories, “Lakes and Rivers”, “Reservoirs” and “Other wetlands”. Two categories are considered unmanaged. Reservoirs, which are classified as wetland remaining wetland, include only lakes and rivers turned into reservoirs. In cases where the water surface area of the lake has increased only, the lake area before the increase is defined as wetland remaining wetland. No emissions are assumed from natural lakes converted to reservoirs. Peat mining for fuel does not occur. The only peat excavation currently occurring is related to land converted to settlement (Chapter 7.7.1.).

Some of the land included under other wetlands could fall under managed land due to livestock grazing and should be reported as such; no information is at present available on the area of grazed peatlands. Drained peatlands are reported as wetlands converted to grassland and regarding “Non CO_2 emission” under subcategory “Other- Grassland organic soil”. All lakes and rivers are considered unmanaged.

The subcategories ‘Wetland remaining wetland -other wetland ’ and ‘Wetland remaining wetland- lakes and rivers’ are identified as key areas with regards to reported land use categories at highest resolution reported Table 7.10. When considering only main land use categories the category Wetlands remaining wetlands are also recognized as key area.

7.15.1.1 Flooded land

CO_2 emission from reservoirs are presented for three subcategories:

- Grassland with high soil organic carbon content (High SOC). SOC higher than 50 kg C m^{-2}.
- Grassland with medium soil organic content (Medium SOC). SOC 5-50 kg C m^{-2}.
- Other land with low soil organic content (Low SOC). SOC less than 5 kg C m^{-2}.

The emissions are from flooded land are estimated either on the basis of classification of reservoirs or parts of land flooded to these three categories or on basis of reservoir specific emission factors available (Óskarsson and Guðmundsson 2008). Reservoir classification is based on information from hydro-power companies using relevant reservoir on area and type of land flooded.

The emissions are calculated from the emission factors available, reservoir area and estimated length of ice-free period. No meteorological data is available on ice-free period of lakes or reservoirs but 215 days are assumed as an average number of ice-free days, like in previous submissions. The estimated CO_2 emissions from reservoirs equal 16.18 Gg. This number has not changed since last year’s submission.

7.15.2 **Other emissions (5II)**

Emission of N_2O from drained wetlands are reported under subcategory “5.G Other-Wetland converted to Grassland Non CO_2 emission 5(II) Non CO_2 emissions from drainage of soils and wetlands- organic soils”.

7.15.2.1 Flooded land

Emissions of CH_4 from reservoirs are reported here. Emissions of CH_4 are estimated applying a comparative method as for CO_2 emission using either reservoir classification or a reservoir specific emission factor for relevant reservoir available (Óskarsson and Guðmundsson, 2008). Emissions of N_2O are considered as not occurring. Tier 1 method of the AFOLU Guidelines includes no default emission factor for N_2O and zero emissions were measured in a recent Icelandic sudy on which the emission estimate is based (Óskarsson and Guðmundsson, 2008).

Estimated CH_4 emissions from reservoirs equal 0.66 Gg CH_4. The emissions have increased from last submission by 73% due to a new reservoir, Hálslón.

7.15.3 **Emission factors**

Reservoir specific emission factors are available for one reservoir classified as High SOC, one reservoir classified as Medium SOC and five classified as Low SOC. For those reservoirs, where specific emission factors are not available, the average of emission factors for the relevant category is applied for the reservoir or part of the flooded land if information on different SOC content of the area flooded is available.

Table 7.13 Emission factors applied to estimate emissions from flooded land (Óskarsson and Guðmundsson 2008)

Emission factors for reservoirs in Iceland	Emission factor [kg GHG ha-1 d-1]			
Reservoir category	**CO_2 ice free**	**CO_2 ice cover**	**CH_4 ice free**	**CH_4 ice cover**
Low SOC				
reservoir specific	0.23	0	0.0092	0
reservoir specific	0.106	0	0.0042	0
reservoir specific	0.076	0	0.003	0
reservoir specific	0	0	0	0
reservoir specific	0.083	0	0.0033	0
average	0.099	0	0.00394	0
Medium SOC				
reservoir specific	4.67	0	0.187	0.004
High SOC				
reservoir specific	12.9	0	0.524	0.012

Emission factors include diffusion from surface and degassing through spillway for both CO_2 and CH_4 and for the latter also bubble emission.

7.15.4 Land converted to wetland

Two sources of land converted to wetland are recognized: flooding due to construction of new hydropower reservoirs and reclamation of wetland to counteract damaged wetlands due to road building or as recreational area connected to tourism. Land flooded is reported as Grassland converted to Wetland, (high or medium SOC) or as "Other land converted to Wetland" (low SOC) depending on vegetation cover. All flooded land is kept in conversions stage although most of the land has been flooded for more than ten years.

7.15.5 Uncertainty and QA/QC

The main uncertainty is associated with the emission factors used and how well they apply to reservoirs of different age. The emission factors for CH_4 are estimated from measurements on freshly flooded soils. The CO_2 emission factors are based on measurements on reservoir flooded 15 years earlier. The information on area of flooded land is not complete and some reservoirs are still unaccounted for. This applies to reservoirs in all reported categories. The same number of days for the ice-free period is applied for all reservoirs and all years. This is a source of error in the estimate.

7.15.6 Planned improvements regarding Wetland

Improvements regarding information on reservoir area and type of land flooded are planned. Introduction of reservoir specific emission factors for more reservoirs is be expected as information on land flooded is improved. Recording and compiling information on the ice-free period for individual reservoirs or regions is planned. Information on how emission factors change with the age of reservoirs is needed but no plans have been made at present to carry out this research.

The development of IGLUD in the coming years is expected to improve area estimates for wetland and its subcategories.

7.16 Settlements

The area of Settlement reported is the area estimate of IGLUD. Compared to the area estimate in last year's submission (86.47 kha) the present estimate is considerable lower (71.06 kha). This difference is due to two main reasons. Firstly the map layer of roads has been modified such that no buffer is now applied on smaller roads and tracks. That map layer is therefore 12.6 kha smaller than the one used last year. Secondly the order of compilation has been modified. Instead of compiling the maps of main land use categories individual map layers are compiled as described in Table 7.2. Accordingly the map layers of Forest Land are ranked higher than the Settlement layers of "Green urban areas" and "Sport and leisure facilities".

7.16.1 **Carbon stock changes (5E)**

The AFOLU Guidelines are more extensive with respect to reporting emission from settlements and land converted to settlement than the previous GPG for LULUCF, where focus was only on stock changes in living tree biomass for this category.

Carbon stock changes are only estimated for Forest land converted to Settlement. The emissions reported are based on carbon stock estimates of the living biomass of the trees on the deforested land. No land is reported in the inventory year as Forest land converted to Settlement.

Potential sources of emissions and removals by sinks involve excavated organic soils as sources and growth of trees, shrubs and herbaceous vegetation as sinks.

Organic soils are sometimes excavated and used in landscaping or for other purposes when former wetlands areas converted into settlements or areas already included under settlement are prepared for construction of streets or buildings. This excavation of organic soil enhances decomposition of the organic material and emissions of both CO_2 and N_2O. This source is not estimated in the inventory. There is no data presently available on the amount extracted.

Part of the drained land is within the area classified as Settlement. Due to disaggregation of drained land to individual land use categories drained organic soils in Settlement area are not included as drained Grassland soils and no emissions are reported for this land in this year's submission. The total overlap of Settlement map layers after compilation in to IGLUD with the map layer of drained land before compilation in IGLUD is 17 kha, representing a maximum estimate for the size of drained land within Settlement. The methodology for estimating the emission from this potential source has not yet been elaborated.

Newly established neighbourhoods have in general less vegetation both woody and herbaceous than older neighbourhoods. This increase in biomass is not estimated in the inventory.

7.16.2 **Other emissions (5)**

As discussed above the area of drained wetlands, which is inside Settlement has not been estimated. The N_2O emissions due to this land use have not been estimated in this year's submission since the methodology and area estimate need to be elaborated. Burning of biomass in open areas within the category Settlement does take place (see chapter 0). No other sources of CH_4 or N_2O have been recognized.

7.16.3 **Land converted to settlement**

At present no official country-wise periodic compilation of land converted to settlement has been made. Previous land use categories are generally not recorded in municipal area planning. NLSI has prepared CLC-2000 maps from CLC 2006/2000 changes. The recording of these CLC 2006/2000 changes are limited to few categories and most of them are included under Settlement. The CLC 2000 maps do accordingly hold information on land converted to settlement but have not yet been included in IGLUD.

7.16.4 Planned improvements regarding Settlement

The present estimate of Settlement area is based on CLC 2006 maps. The adaptation of CLC 2000 data into IGLUD is in coming years expected to support time series for Settlement area.

Part of land identified as Settlement is on drained wetland soils. In this year's submission the drained wetland soils were disaggregated and reported separately for Grassland and Cropland plus Forest Land. This means that drained land under settlement is no longer included as "Wetland converted to Grassland" as in previous submissions. A geographic identification of the drained land under Settlement and an independent estimate of emissions from that area is planned in coming years.

7.17 Other land (5, 5F)

No emission/removal is reported for "other land remaining other land" in accordance with AFOLU Guidelines. Conversion of land into the category "Other land" is not recorded. Direct human induced conversion in not know to occur. Potential processes capable of converting land to other land are, however, recognized. Among these is soil erosion, floods in glacial and other rivers, changes in river pathways and volcanic eruptions.

The area reported for "Other land" is the area estimated in IGLUD. Other land in IGLUD is recognized as the area of the map layers included in the category remaining after the compilation process (see Table 7.2). The map layers included in the category "Other land" are of areas with vegetation cover < 20 % or covered with mosses. Also included is the map layer of "Revegetation area 1996-2008 with vegetation cover <33%". This map layer includes land defined as revegetation area but not necessary land where active revegetation has been done. Possibly, some of this area represents revegetation activity before 1990 where revegetation failed, and should accordingly not be defined as unmanaged land.

7.17.1 Planned improvements regarding other Other Land

The development of IGLUD in coming years is expected to improve area estimates for the category. Especially, improvements regarding mapping of revegetation activities before 1990, are expected to improve the quality of mapping of the "Other land" category.

7.18 Other (5)

Two emission/removal categories are reported under other. Wetland converted to Grassland Non-CO_2 emission and emission/removal due to use of fertilizers in revegetation. Harvested Wood Products are not reported.

7.18.1 **Harvested Wood Products**

No data is available on stock changes in harvested wood products and therefore not been estimated. There are no planned improvements regarding recording of this stock.

7.18.2 **Wetland converted to Grassland Non CO_2 emissions**

Under this item non-CO_2 emissions from wetland converted to grassland are reported as aggregate estimate for all drained soils except for those included under Forest land. The present structure of Reporter software (version 3.4.3) does not allow reporting of these emissions under the Grassland land use category, as the category “5(II) Non-CO_2 emissions from drainage of soils and wetlands- Organic soils” is not included under Grassland tables.

7.18.2.1 Other emissions (5(I), 5(II), 5(III)

Grasslands in Iceland are not generally fertilized. The main exception is fertilization as part of a revegetation activity. Use of fertilizers in revegetation is reported separately (see below). Direct N_2O emissions from eventual use of N fertilisers on grassland are included under emissions from agricultural soils.

Emissions of N_2O due to drainage of organic soils of Grassland are reported here under “5(II) Non-CO_2 emissions from drainage of soils and wetlands- Organic soils”. This factor is identified as level key source of LULUCF.

7.18.2.2 Emission factors

Emissions of N_2O from drained organic soil of Grassland are calculated according to Tier 2 using emission factor EF=1.8 [kg N_2O-N ha-1 yr-1] (AFOLU Guidelines Table 7.6) for nutrient rich organic soils considering the high N content. In “Report of the individual review of the annual submission of Iceland submitted in 2009” (UNFCCC 2010) it is recommended to report N_2O emission from drained Grassland is reported in agriculture sector and apply EF = 8.0 [kg N_2O-N ha-1 yr-1] the default EF value from table 4.17 in “IPCC Good Practice Guidance and Uncertainty management in National GHG inventories”. The application of the EF from AFOLU Guidelines Table 7.6 has been reconsidered. The drained organic soils of Cropland are now reported in agricultural sector. The drained grassland soils in Iceland have not been ploughed sown or fertilized and are not agricultural soils as cultivated soils. In a recent research project on GHG emissions from organic soils of variable land use the emission of N_2O from drained organic grassland soil were estimated as 0.4 [kg N_2O-N ha-1 yr-1] (Gudmundsson 2009) which is considerable lower value than the EF used and far lower than the recommended default EF for agricultural soil. Considering this it was decided to use the AFOLU guidelines Table 7.6 EF in this year’s submission for estimating N_2O emission from drained organic grassland soils. The notation key for the method applied and EF used are also revised as being more appropriately being Tier 2 and Country Specific rather than Tier 1 and Default as in previous submissions.

7.18.3 Revegetation

7.18.3.1 Other emissions (5(I), 5(II), 5(III))

The direct emissions of N_2O from the use of N-fertilizers on revegetated land are reported here.

7.18.3.2 Emission factors

For direct N_2O emission from N fertilization Tier 1 and default EF=1.25% [kg N_2O-N/kg N input] (GPG2000) were used.

7.19 Biomass burning (5V)

Accounting for biomass burning in all land use categories is addressed commonly in this section. The only emission reported is for the year 2006 due to single large wild-fire event in western Iceland.

No other emissions due to biomass burning are reported. Controlled burning of forest land is considered as not occurring. The same applies to land converted to forest land, land converted to cropland, forest land converted to grassland, forest land converted to wetland and wildfires on forest land converted to: cropland, grassland or wetland. It is not estimated for other categories due to lack of information.

Burning the biomass on grazing land near the farm was common practice in sheep farming for a long time. This management regime of grasslands and wetlands is becoming less common and is now subjected to official licensing. The recording of the activity is minimal although formal approval of the local police authority is needed for safety and for birdlife protection purposes.

7.19.1 Planned improvements regarding biomass burning

A large wildfire broke out in the year 2006. It initiated a research project aimed at assessing the effects of biomass burning on ecosystems. This project is expected to provide data for a Tier 2 assessment of amount of biomass burned per area. Systematic compilation of existing information on approved burning and improved recording of the controlled and wild-fire is planned.

7.20 Planned improvements of emission/removal data for LULUCF

Improvements which apply specifically to one of the land use categories and activities, or one of their pools are listed above in their relevant chapters.

In parallel with gathering of land use information for the purpose of the new geo-referenced land use database IGLUD, data will be collected regarding the carbon stocks of the land use category used in the classification. These efforts are aimed at gradually improving the reliability of reported emission/removal of the LULUCF

sector and enable the transfer from Tier 1, which is presently used to calculate emission/removal in many categories, to higher tier levels.
The results of ongoing and recent research activity on emissions/removal and stocks in several ecosystems will be implemented in emissions calculations.

8 WASTE

8.1 Overview

This sector includes emissions from solid waste disposal in landfill sites (landfills), wastewater treatment, small scale waste incineration, and Other (composting).

The waste sector has been in transition since 1990 (Figure 8.1 and Figure 8.2). Open pit burning which used to be the most common means of waste disposal outside the capital area has gradually decreased since 1990 as landfills have become more common. No open pit burning takes place in Iceland now, except for bonfires during New Year celebration. The trend has been toward managed landfills as municipalities have increasingly cooperated with each other on running waste collection schemes and operating joint landfill sites. This has resulted in larger landfills and enabled the shutdown of a number of small sites. Today, 56% of solid waste is sent to managed landfill sites for disposal. Recycling of waste has also increased due to efforts made by local municipalities. Composting started in 1995 and has become an option in waste treatment as composting facilities have been taken into operation in recent years. Currently about 36% of municipal waste is landfilled, 58% recycled or recovered, 4% incinerated with energy recovery and 1% is composted.

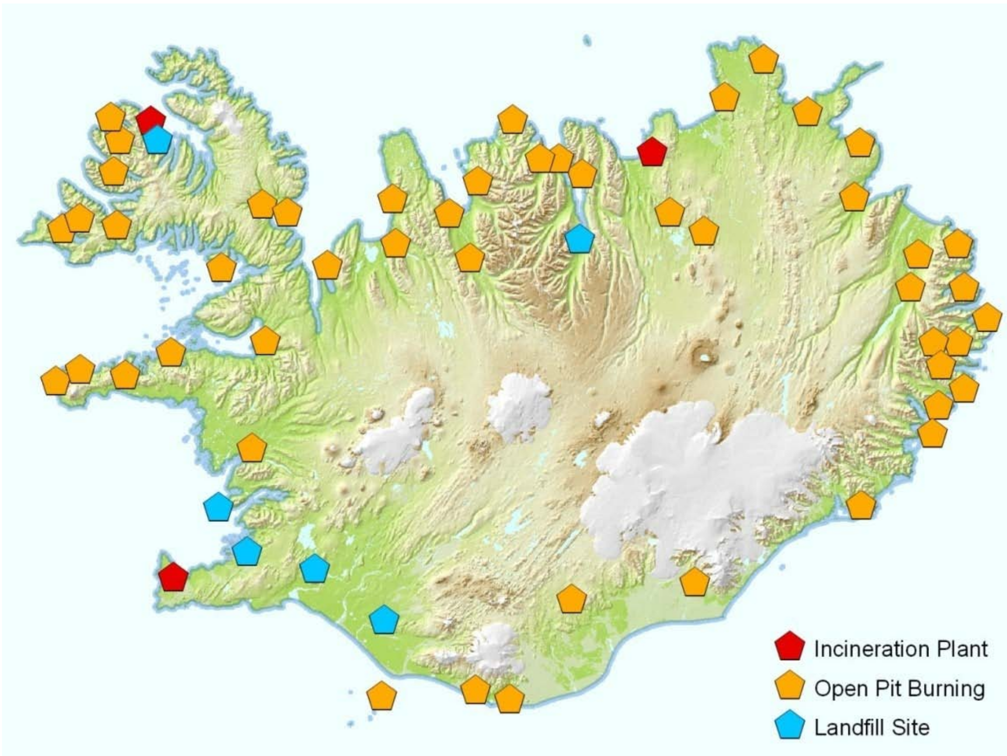

Figure 8.1 Solid waste disposal in 1990

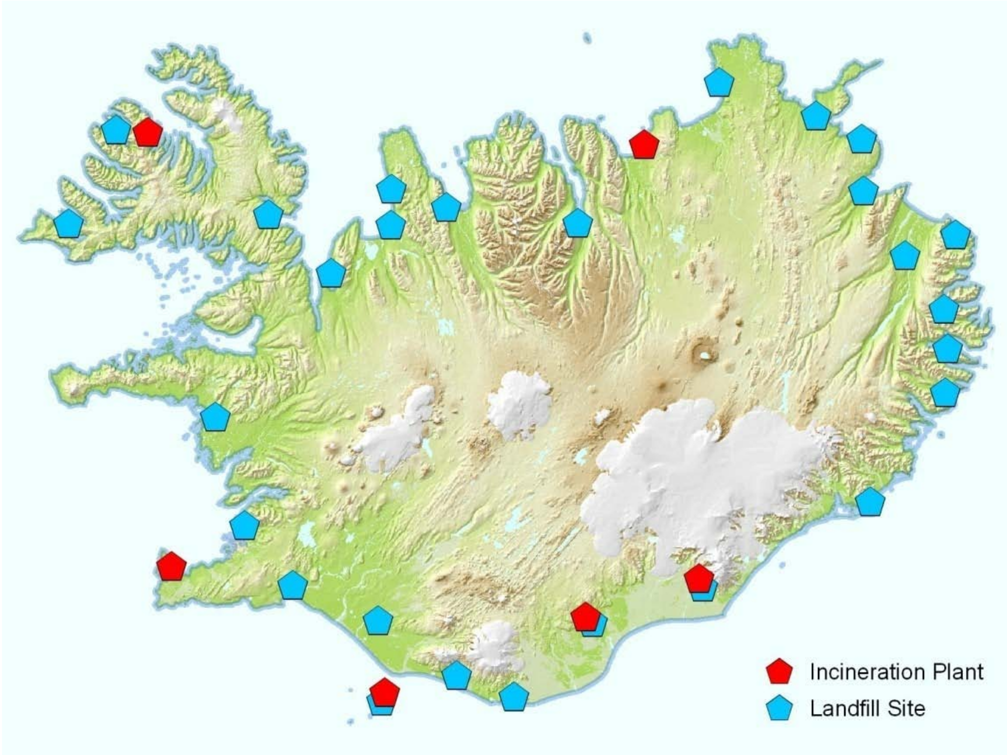

Figure 8.2 Solid waste disposal in 2008

The majority of the Icelandic population, approximately 90%, lives by the coast, a non-problem area with regard to eutrophication, as Iceland is surrounded by an open sea with strong currents and frequent storms which lead to effective mixing. About 65% of the population lives in the capital area. Most of the larger industries are within this area, located mostly at the coast. The practice of wastewater treatment has undergone a radical change in Iceland since 1990. In 1990, 6% of the Icelandic households and industries were connected to wastewater treatment plants, but in 2008 the ratio was 68%.

Landfills are the most important source of CH_4 emission in this sector. Wastewater handling is a minor source of CH_4 as only a minor part of wastewater treatment is anaerobic. Landfills account for about 86% of the sector's total emissions. Wastewater handling and waste incineration account for 5% and 9% respectively. Composting accounts for less than 1%. The waste sector accounted for 4% of the total GHG emissions in Iceland in 2008.

8.1.1 **Methodology**

The calculation of greenhouse gas emissions from waste is based on the methodologies suggested by the IPCC Guidelines and the Good Practice Guidance. Methodology for each category within the waste sector is described separately below.

8.1.2 Key sources

As indicated in Table 1.1, the key source analysis performed for 2008 has revealed that in terms of total level and/or trend uncertainty, the only key sources in the waste sector is Emissions from Solid Waste Disposal Sites – CH_4 (6A)

8.1.3 Completeness

Table 8.1 gives an overview of the IPCC source categories included in this chapter and presents the status of emission estimates from all sub-sources in the industry sector.

Table 8.1 Waste – completeness (E: estimated, NE: not estimated, NA: not applicable)

	Direct GHG			Indirect GHG			
	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Solid waste disposal on land							
Managed waste disposal on land	NE	E	NA	NA	NA	NE	NA
Unmanaged waste disposal on land	NE	E	NA	NA	NA	NE	NA
Wastewater treatment							
Industrial wastewater	NE	E	NE	NE	NE	NE	NE
Domestic and commercial wastewater	NE	E	E	NE	NE	NE	NE
Waste incineration	E	E	E	E	E	E	E
Other – Composting	NE	E	E	NA	NA	NA	NA

8.1.4 Source specific QA/QC procedures

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

8.2 Solid waste disposal sites

Methane from solid waste disposal sites is emitted during the biological decomposition of waste. This transformation of organic matter takes place in several steps. Decomposition is aerobic during the first weeks or months, and the main decomposition product is CO_2. When the oxygen is depleted the decomposition becomes anaerobic and methane levels start to increase and a peak is seen in CH_4 emissions. The level then decreases over several decades. The length of the individual phases is dependent on type of landfills, type of waste, and environmental factors including oxygen, hydrogen, pH, alkalinity, temperature and moisture content. Well managed deep landfills have a much greater capacity for CH_4 production than shallow unmanaged sites, where aerobic conditions may dominate.

Solid waste disposal in Iceland is divided between managed landfill sites and unmanaged landfill sites. The definition for a managed site is a landfill deeper than 5 meters with a thorough registration system for waste type and amount. Sites that are shallow, with less than 5 meters of waste are defined as unmanaged landfill sites.

This division is in line with measurements made by Kamsa and Meyles (2003) where methane concentration in smaller landfills (thickness less than 4 meters) was lower than 20%. Total waste going to landfills is divided into two major waste streams, municipal solid waste (MSW) and industrial waste (IW) as the CH_4 production potential of solid wastes is determined by the amount of degradable organic carbon (DOC) in the waste.

The methodology for calculating methane from solid waste disposal on land is in accordance with the IPCC First Order Decay Model. MSW is defined as waste collected from households, commerce and trade and IW is waste collected from industry. Waste from commerce and trade can be included both in MSW and IW, especially in smaller municipalities where separation between MSW and IW is not well specified. Inactive waste, such as demolition, scrap metal and tires is excluded from the IW figures, but included in official data on Solid waste disposal sites in Iceland.

8.2.1 Activity data

Activity data on waste in Iceland has proven to be insufficient in past years. There is little information available about the actual amounts of waste generated before 1990. The same applies to the composition and characteristics of the waste. Reporting of the amounts of waste received by managed landfill sites started after 1980. The reporting is handled by landfill operators. Estimation exist on total waste generation from 1995. Consistent and relatively reliable data sets on total waste generation and treatment are available from 2004 and later.

In line with IPCC guidelines, historical data was calculated by extrapolation from 1994 back to 1950 using Gross Domestic Product (GDP), and population as drivers. These parameters are considered reliable. GDP is correlated with a country's waste production and is a reliable estimation method. Available reported waste figures, since 1995, GDP and population are used to estimate the total amount of waste generated from 1950 to 1995. From 1950 to 1980, all waste disposal is rated as uncategorized as waste management was poor and uncontrolled in these years and private incineration was common with nonexistent waste management.

GDP based calculation uses waste figures generated in 1995, 2000 and 2004 as multiple reference figures. GDP and MSW per person, which are strongly correlated, were used to determine the amount of generated MSW per person per year and multiplied by population to obtain the total MSW figures. Industrial waste, however, was extrapolated by using GDP as the only driver. Data quality for the multiple reference years is ensured by accurate waste reporting during those years. A fluctuation is seen in the relationship between GDP and waste per capita in the years from 1994 to 2008, as the economy of Iceland was not in equilibrium during that time. GDP increased rapidly in the years 2000-2007, with a sudden drop in 2008 (Figure 8.3).

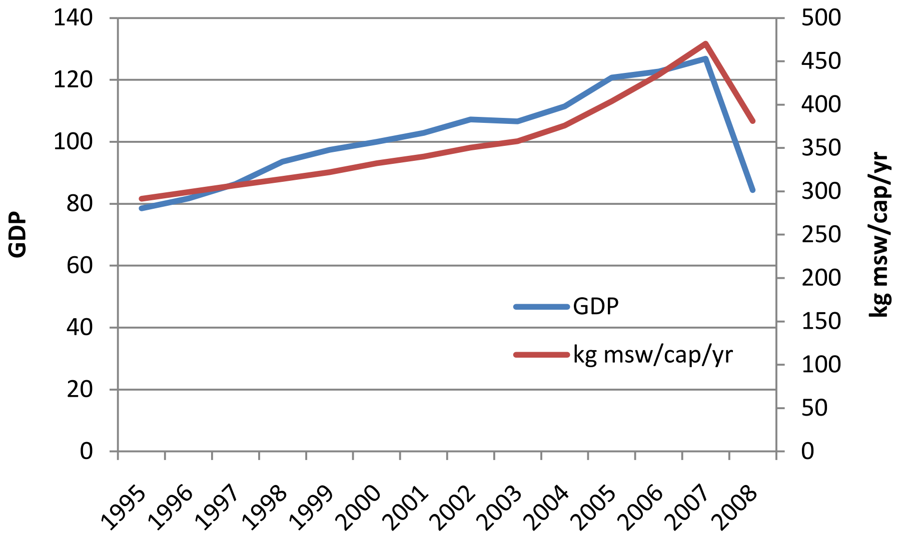

Figure 8.3 Relationship between GDP an Municipal waste generation 1994-2008

The activity data was mostly collated by the EA through electronic reporting form. The municipalities and larger waste companies are secondary data sources. Division of waste treatment in Iceland between 1990 and 2008 is shown in Figure 8.4. Recycled waste is excluded. The decrease seen in 2006 and 2007 is due to an increase in country-wide recycling and more through data on waste management.

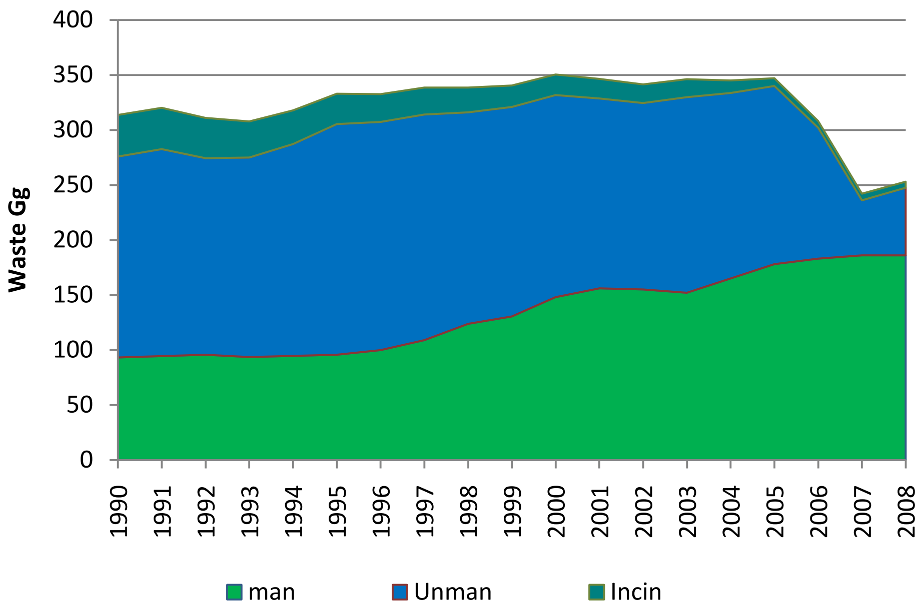

Figure 8.4 Division of waste management from 1990 – 2008. Man = managed waste disposal sites, Unman = Unmanaged waste disposal sites, Incin = Incineration

8.2.2 Emission factors

Municipal solid waste

Municipal Solid Waste corresponds to waste from households and similar waste from commerce and trade. MSW can be disaggregated into a mix of waste categories that contain significant fractions of biodegradable carbon: food, garden, paper, wood, textile and nappies.

The composition of MSW going to landfills has been surveyed since 1999 by SORPA, the largest waste treatment facility in Iceland. SORPA serves the capital area and thus covers around 63% of the Icelandic population. The composition of MSW over the last 7 years has shown to be relatively consistent. Because very little is known about the MSW composition before 1999, the average composition from 1999 to 2004 has been used in the IPCC model for each year between 1950 and 2008.

It is understood that the composition of MSW is likely to have changed over the last 60 years. For example, the fraction of garden waste in 1950 may have been higher than in 2000 and the fraction of plastic (packaging) waste is expected to have increased significantly since 1950.

A sensitivity analysis, however, showed very little variation in total methane emissions in Sector 6A when applying different waste compositions between 1950 and 2004. The difference calculated did not exceed 2%. The composition of MSW has not been further investigated because it is impossible to estimate the exact composition of waste each year and it has very little effect on the final outcome. The results of the waste composition surveys for 1999 to 2004 and their averages are reported in Table 8.2.

Table 8.2 Municipal Solid waste composition survey results 1999 – 2004

Type of waste	1999	2000	2001	2002	2003	2004	Average
Food waste	33%	28%	31%	26%	24%	26%	28.1%
Garden waste	4%	0%	1%	0%	2%	1%	1.4%
Paper and Cardboard	24%	29%	21%	22%	26%	27%	24.8%
Wood waste	0%	1%	1%	1%	1%	0%	0.6%
Textile waste	4%	4%	3%	3%	3%	4%	3.4%
Diapers/nappies	5%	4%	6%	7%	5%	6%	5.6%
Sludge	4%	4%	4%	4%	4%	4%	3.9%
Plastics, other inert	26%	30%	33%	37%	35%	32%	32.2%

Sludge was excluded from this composition when calculating emission from MSW. Proper wastewater handling started around 1990. Septic tanks were used prior to that to some extent, and were the only existing treatment. Today, 68% of buildings are connected to municipal wastewater handling facilities. Little is known of sludge disposal prior to 1990 and the amount that was disposed in landfills is considered insignificant. Emissions from sludge in landfills are included in landfill emissions from the year 1990. Parameters used are in accordance with IPCC default values for northern Europe and wet temperate conditions, except for the country specific values for MSW composition. The parameters for IPCC Category 6A Municipal Solid Waste are reported in Table 8.3.

Table 8.3 Parameters for Municipal Solid Waste

	Food	Garden	Paper	Wood	Textile	Nappies
MSW composition (average 1999 -2004)	29.2%	1.5%	25.8%	0.6%	3.5%	5.8%
Methane Correction Factor (MCF) - Unmanaged-shallow* - Managed* - Uncategorized*	 0.4 1.0 0.6					
Fraction of degradable organic carbon dissimilated (DOC_F)*	0.5					
Degradable organic carbon (DOC)*	0.15	0.2	0.4	0.43	0.24	0.24
Methane generation constant (k)*	0.185	0.1	0.06	0.03	0.06	0.1
Half-life time (h) (years) (h = Ln(2)/k)	4	7	12	23	12	7
Delay time (month)*	6					
Number of considered years	56					
Fraction of CH_4 in landfill gas (F) *	0.5					
Oxidation factor (OX) *	0.05					
Conversion factor (C to CH_4)	1.33					

* IPCC default value for northern Europe and wet temperate conditions

Industrial waste

Iceland's economy has historically depended heavily on the fishing industry. The main material exports now are fish and fish products and aluminium. Iceland's agricultural products consist mainly of potatoes, green vegetables (in greenhouses), mutton and dairy products.

Industrial waste (IW) comes from agriculture, fisheries and other industrial activities as well as commerce and trade (fraction not included in MSW). The amount of IW used in the IPCC model does not includes separated waste fractions such as scrap metal, tires and construction and demolition waste. These data are included in official data on Solid waste disposal sites in Iceland. It is expected that significant fractions of MSW-related waste can be found in IW and this is further explained in the section on Uncertainties.

As no national data are available on emissions from landfill waste, default IPCC data for northern Europe and wet temperate conditions are used. The emission factors and parameters for IPCC Category 6A Industrial Waste are reported in Table 8.4.

Table 8.4 Parameters for Industrial Waste

Parameters	
Methane Correction Factor (MCF) - Unmanaged-shallow* - Managed* - Uncategorized*	 0.4 1.0 0.6
Fraction of degradable organic carbon dissimilated (DOC_F)*	0.5
Degradable organic carbon (DOC)*	0.15
Methane generation constant (k)*	0.09
Half-life time (h) (years) (h = Ln(2)/k)	8
Delay time (month)*	6
Number of considered years	56
Fraction of methane in landfill gas*	0.5
Oxidation factor (OX) *	0.05
Conversion factor (C to CH_4)	1.33

* IPCC default value for northern Europe and wet temperate conditions

Landfill gas recovery

Iceland's only landfill gas recovery facility is at Álfsnes, a landfill which receives waste from the capital area. It serves 65% of the population and receives 50% of the total amount of landfilled waste. The recovery of CH_4 from the landfill started in 1997 and the amounts are reported in Table 8.5. Methane recovery was significantly less in 2006 and 2007 than in 2005 as the local power plant failed and the methane burner did not operate during the first half of 2006. This led to the reduction of captured methane from the landfill. Due to this reduction, water accumulated in the landfill which led to further disruption in the recovery of landfill gas in 2007. The values for methane recovery in 2006 and 2007 are estimated. In 2008, methane recovery was measured 16 Gg CO_2 eq which is significantly less than in previous years. This dissimilarity in methane recovery between 2005 and 2008 is currently under revision.

Table 8.5 Landfill gas recovery in Iceland, Gg CO_2 equivalents from 1997 to 2008

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Landfills	2	5	7	9	9	23	24	29	33	19	9	16

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CH_4 emissions from solid waste disposal sites is 52%. The quality of the activity data for Iceland may be considered sufficient, but needs further improvement to ensure its accuracy and quality. The uncertainties in the IPCC model for Sector 6A are as follows:

Landfilled waste between 1950 and 1980

The exact amount of waste going to managed or unmanaged landfill sites between 1950 and 1980 is unknown. Therefore the Methane Correction factor (MCF) in the IPCC model has been set to uncategorized for this period (MCF = 0.6 – see Table 8.3 and Table 8.4).

Amount and composition of Industrial Waste

The exact composition of mixed IW and thus the fraction of biodegradable waste are unknown. Scrap metal, tires and construction and demolition waste are excluded from the total. Large amounts of waste from companies are similar in composition to MSW; this is included in the mixed fraction of Industrial Waste. Methane emissions from landfilled IW might be overestimated as studies have revealed that methane emissions from landfills that accept slaughterhouse waste is very low, as this type of waste decomposes at a slow rate.

MSW composition between 1950 and 1998

The composition of MSW for the years 1950 to 1998 is difficult to estimate. The sensitivity analysis, using different estimated waste compositions showed very little change in total methane emissions. The calculated differences in total methane emission in Sector 6A did not exceed 2%.

Methane recovery

Methane recovery has been measured and estimated in recent years, uncertainty of estimation is not known.

8.3 Emission from Wastewater Handling (6B)

8.3.1 Domestic Wastewater

Most of the few wastewater treatment plants that have been built in Iceland are located in the capital area and a few other larger municipalities. The wastewater treatment systems are mostly settling tanks or septic tanks, with primary and secondary treatment. Improvements have been made in the last decade to bring the sewage system to an acceptable level. The improvements, made in the capital area, included:

1) consolidation of the drainage system reduced the number of outlets from 40 to two,
2) the sewage is being pumped out through the outlets into an ocean area 4 km from the land, where mixing is vigorous,
3) treatment of sewage with measures comparable to primary treatment.

Only about 6% of the population is living in rural areas and fewer than 1000 people live above 200 m altitude. This explains the high percentage of primary treatment. In 2007 one of the municipalities located close to Reykjavík that had been using septic tanks as an treatment system was connected to the Reykjavik draining system. This led to a decrease in overall emissions from wastewater handling.

The sludge from wastewater handling is disposed of in (managed and unmanaged) landfill sites. As no wastewater treatment existed prior to 1990, and little is known of where sludge was placed earlier, it is assumed that placing of sludge in landfills started in 1990 in connection with wastewater treatment plants.

Methodology

The prevalent treatment of wastewater is aerobic, 57% is primary treatment and 32% has no treatment. 2% of the treatment has secondary treatment and 8% are septic tanks. Methane correction Factor is chosen in line with IPCC guidelines and EA specialists (table 6.3).

Methane emissions

The general equation to estimate CH_4 emission from domestic wastewater is as follows:

Total CH_4 emissions from Domestic Wastewater:

$$CH_4\ Emission = \left[\sum_{i,j}\left(U_i \cdot T_j \cdot EF_j\right)\right](TOW - S) - R$$

CH_4 Emissions = CH_4 emissions in the inventory year, kg CH_4/yr
TOW = Total organics in wastewater in inventory year, kg BOD/yr
S = Organic component removed as sludge in inventory year, kg BOD/yr
U_i = Fraction of population in income group *i* in inventory year
T_j = Degree of utilization of treatment/discharge pathway or system, *j*, for each income group fraction *i* in inventory year
j = Each treatment/discharge pathway or system
EF_j = Emission factor, kg CH_4/kg BOD
R = Amount of CH_4 recovered in inventory year, kg CH_4/yr

CH_4 Emission Factor for Each Domestic Wastewater Treatment/Discharge Pathway or System:

$$EF_j = B_o \cdot MCF_j$$

EF_j = Emission factor, kg CH_4/kg BOD
j = Each treatment/discharge pathway or system
B_o = Maximum CH_4 producing capacity, kg CH_4/kg BOD
MCF_j = Methane correction factor (fraction)

Activity data:

$$TOW = P \cdot BOD \cdot 0.001 \cdot I \cdot 365$$

TOW = Total organics in wastewater in inventory year, kg BOD/yr
P = Country population in inventory year (person)
BOD = Country-specific per capita BOD in inventory year, g/person/day
0.001 = Conversion from grams BOD to kg BOD
I = Correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, for uncollected the default is 1.00)

Total domestic organic sludge:

$$S = P \cdot D_{dom} \cdot DS_{dom}$$

S = Organic component removed as sludge in inventory year, kg BOD/yr
P = Country population in inventory year
D_{dom} = Domestic degradable organic component in kg BOD/100 person/yr
DS_{dom} = Fraction of domestic degradable organic component removed as sludge

Emission factors

Of the total population connected to wastewater handling facilities, most are connected to Primary treatment, some are connected to handling facilities such as septic (and settling) tanks. In 2002, secondary treatment (two step treatment) was introduced on a small scale. A different Methane Corrector Factor applies to these handling methods. The MCF used is in accordance with the IPCC 2006 guideline default values (table 6.3) and EA specialists. Primary treatment is most common, where little treatment exist as the wastewater is led to the sea (MCF = 0.1). Few secondary treatment facilities exist, the wastewater is treated to some extent, although the treatment is mostly aerobic (MFC = 0.3), the rest is septic systems (MFC = 0.5). Parameters for IPCC Category 6B Wastewater Handling are reported in Table 8.7.

Nitrous oxide

N_2O emissions were estimated using the IPPC 2006 Guidelines. Variable P (population) in this equation is country specific and includes only the population that is connected to wastewater treatment facilities. Other emission factors are either IPCC default values or estimated values.

Nitrous oxide emissions from human sewage were calculated according to the IPCC default method, which is based on the annual per capita protein intake. Annual protein intake in Iceland is high or 31.76 kg/person/year (Surveys made in 2002-2003).

N_2O emissions from wastewater effluent:

$$N_2O\ Emission = N_{EFFLUENT} \cdot EF_{EFFLUENT} \cdot 44/28$$

N_2O emissions = N_2O emissions in inventory year, kg N_2O/yr
$N_{EFFLUENT}$ = Nitrogen in the effluent discharged to aquatic environments, kg N/yr
$EF_{EFFLUENT}$ = Emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N
The factor 44/28 is the conversion of kg N_2O-N into kg N_2O

Total Nitrogen in the Effluent:

$$N_{EFFLUENT} = (P \cdot Protein \cdot F_{NPR} \cdot F_{NON-CON} \cdot F_{IND-COM}) - N_{SLUDGE}$$

$N_{EFFLUENT}$ = Total annual amount of nitrogen in the wastewater effluent, kg N/yr
P = Human population
Protein = Annual per capita protein consumption, kg/person/yr
F_{NPR} = Fraction of nitrogen in protein, default = 0.16, kg N/kg protein
$F_{NON-CON}$ = Factor for non-consumed protein added to the wastewater
$F_{IND-COM}$ = Factor for industrial and commercial co-discharged protein into the sewer system
N_{SLUDGE} = Nitrogen removed with sludge (default = zero), kg N/yr

Activity data

The activity data used for estimation of N_2O is represented by the population portion that is connected to wastewater handling facilities and is reported in Table 8.6. The total number of population is obtained from the Statistics Iceland.

Table 8.6 Total population and population connected to wastewater handling facilities in Iceland

	Population	Connected to wastewater facilities			
		Total	Primary treatment	Secondary treatment	Septic tanks
1990	255,708	6%	2%	0%	4%
1995	267,806	10%	4%	0%	6%
2000	282,849	39%	33%	0%	6%
2005	299,404	68%	54%	2%	11%
2006	307,261	68%	54%	2%	11%
2007	315,459	68%	57%	2%	9%
2008	319,368	68%	57%	2%	9%

Emission factors

Annual per capita protein intake is based on Dietary Surveys of the Icelandic Nutrition Council and the Dietary Survey Unit for Nutrition Research performed in 2002-2003, more recent data on protein intake are not available. Parameters for IPCC Category 6B Wastewater Handling are reported in Table 8.7.

Table 8.7 Parameters for Wastewater

Parameters	
BOD *	60 g/person/day
MCF_{septic}*	0.5
$MCF_{Primary\ treatment}$*	0.1
$MCF_{Secondary\ treatment}$*	0.3
$MCF_{Untreated}$	0.1
B_o *	0.6 kg CH_4/kg BOD
Protein	31.76 kg/person/year
D_{dom}	18.25kg BOD/person/year
DS_{dom}	15%
F_{NPR}*	0,16kg N/kg protein
$F_{NON-CON}$*	1.4
$F_{IND-COM}$*	1.5
N_{SLUDGE}*	0 kg N/yr
I*	1.25

* IPCC default value

Uncertainties

The uncertainties in the IPCC model for Sector 6B are as follows:

MCF parameter

Default MCF parameters for Domestic Wastewater were used. Most Domestic Wastewater falls under Primary treatment and is pumped out into the sea, therefore MCF = 0.1 was used. Wastewater going through Secondary treatment and Septic tanks where MCF = 0.3 and 0.5 respectively according to IPCC Default MCF values and EA specialist judgement.

$F_{IND-COM}$ parameter

Default IPCC values for $F_{IND-COM}$ range between 1.0 and 1.5. As Iceland has significant fish processing, 1.5 was set as factor to allow for co-discharge of industrial nitrogen into sewers. This factor might be higher.

DS_{dom} parameter

Sludge removed from wastewater treatments are estimated to be 15%, which is based on data on sludge disposed of in landfills as well as results from a survey made on compositions on wastewater treatment plants (Auðunsson 2002).

The calculation of emissions from wastewater handling confirms earlier expectation that very little emission is generated from wastewater handling in Iceland (NIR 2005).

8.3.2 Industrial Wastewater

Emissions from fish, dairy products and meat & poultry industrial wastewater are evaluated as these groups constitute the majority of industrial emissions in Iceland. The Fish processing is the dominant factor in the estimate. Scandinavian data on tonnes COD produced per tonne for different fish groups were used to estimate wastewater handling in the Fish processing industry. For uncategorized fishing (fish species that are captured as by-catch), Meat & Poultry and dairy products, default IPCC values were used.

The following equations were used to estimate Industrial Wastewater.

Total CH_4 Emissions from Industrial Wastewater:

$$CH_4 Emissions = \sum_i [(TOW_i - S_i)EF_i - R_i]$$

CH_4 Emission = CH_4 emissions in inventory year, kg CH_4/yr
TOW_i = Total organically degradable material in wastewater from industry *i* in inventory year, kg COD/yr
i = Industrial sector
S_i = Organic component removed as sludge in inventory year, kg COD/yr
EF_i = Emission factor for industry *i,* kg CH_4/kg COD for treatment/discharge pathway or system(s) used in inventory year
R_i = amount of CH_4 recovered in inventory year, kg CH_4/yr

CH_4 Emission Factor for Industrial Wastewater:

$$EF_j = B_o \cdot MCF_j$$

EF_j = Emission factor, kg CH_4/kg BOD
j = Each treatment/discharge pathway or system
B_o = Maximum CH_4 producing capacity, kg CH_4/kg BOD
MCF_j = Methane correction factor (fraction)

Organically Degradable Material in Industrial Wastewater:

$$TOW_i = P_i \cdot W_i \cdot COD_i$$

TOW = Total organically degradable material in wastewater for industry *i*, kg COD/yr
i = Industrial sector
P_i = Total industrial product for industrial sector *i*, t/yr
W_i = Wastewater generated, $m^3/t_{product}$
COD_i = Chemical oxygen demand (industrial degradable organic component in wastewater) kg COD/m^3

Activity data
The activity data used for estimation of Industrial Wastewater emissions is obtained from Statistics Iceland and the Icelandic Dairy Association. Data on COD per tonne product is available for different fish/seafood groups from Scandinavian sources. For dairy products, meat & poultry produce and uncategorized fish catch, the default IPCC values on water usage and COD were used. B_o is also by IPCC default. See Table 8.8.

Table 8.8 Parameters for Industrial Wastewater

Parameters	
COD $_{\text{white fish}}$	17 kg O_2/m^3 COD
COD $_{\text{Herring}}$	22 kg O_2/m^3 COD
COD $_{\text{Shrimp}}$	115 kg O_2/m^3 COD
COD $_{\text{fishmeal (Capelin)}}$ **Fish processing** $_{\text{uncategorised}}$*	1.25 kg O_2/m^3 COD 2.5 kg/m^3 COD
Dairy products*	2.7 kg/m^3 COD
Meat & Poultry	4.1 kg/m^3 COD
B_o**	0.25 kg CH_4/kg COD
MCF	0.1

* IPCC examples value, ** IPCC default value

8.4 Waste incineration

Emissions from waste incineration with energy recovery are reported in sector 1A1a and 1A4a (public electricity and heat production and commercial and institutional heat production). Emissions from waste incineration without energy recovery have decreased by 99% from 1990 to 2008. This is because the total amount of waste being incinerated without energy recovery in Iceland has decreased while increasing levels have been incinerated with energy recovery and thus reported under 1A1a and 1A4a. Waste incineration without energy recovery is virtually non-existent today except for bonfires, where only untreated wood is burned.

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 burnout efficiency of the combustion is also included in the calculation. The activity data are disaggregated into different waste types (e.g. municipal solid waste, industrial waste, clinical waste and hazardous waste)

The following equation is used for calculating CO_2 emissions from waste incineration:

CO_2 Emission Estimate Based on the Total Amount of Waste Combusted:

$$CO_2 Emissions = \sum_i (SW_i \cdot dm_i \cdot CF_i \cdot FCF_i \cdot OF_i) \cdot 44/12$$

CO_2 Emissions = CO_2 emissions in inventory year, Gg/yr
SW_i = Total amount of solid waste of type *i* (wet weight) incinerated or open-burned, Gg/yr
dm_i = Dry matter content in the waste (wet weight) incinerated or open-burned, (fraction)
CF_i = Fraction of carbon in the dry matter (total carbon content), (fraction)
FCF_i= total fossil carbon
OF_i = Oxidation factor, (fraction)
44/12 = Conversion factor from C to CO_2
i = Type of waste incinerated/open-burned specified as follows:

Activity data
Activity data on incinerated waste from major incineration plants have been collected by the EA since 2000. Historic data as well as data on open pit burning not reported to the EA was estimated with the assumption that 500 kg of waste have been incinerated per inhabitant in the communities where waste is known to have been incinerated (both in primitive incineration plants as well as open pit burning) in 1990, 1995 and 2000 and interpolated in the years between. These communities were mapped by EA in the respective years. The data after the year 2000 is considered reliable and data prior to 2000 is considered unreliable.

Emission factors
Data for the estimation of CO_2 from waste incineration are utilised according to the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Values for municipal solid waste (MSW) were estimated using the following equations from the IPCC 2006 guidelines. Parameters for MSW were calculated using the composition of waste according to local data on MSW. Default values for industrial waste were used according to IPCC guidelines. Bonfires are supervised by local authorities, and only timber is allowed as a burning matter. Parameters for bonfires are IPCC default data for wood.

Values for individual parameters are presented in Table 8.9.

Dry Matter Content in MSW:

$$dm = \sum_i (WF_i \cdot dm_i)$$

dm = total dry matter content in the MSW

WF_i = fraction of component *i* in the MSW
dm_i = dry matter content in the component *i*

Total Carbon Content in MSW:

$$CF = \sum_i (WF_i \cdot CF_i)$$

CF = total carbon content in MSW
WF_i = fraction of component *i* in the MSW
CF_i = carbon content in the waste type/material *i* in MSW

Fossil Carbon Fraction (FCF) in MSW:

$$FCF = \sum_i (WF_i \cdot FCF_i)$$

FCF = Total fossil carbon in the MSW
WF_i = Fraction of waste type *i* in the MSW
FCF_i = Fraction of fossil carbon in the waste type *i* of the MSW

Table 8.9 Parameters for waste incineration

Waste Stream	MSW	IW	Bonfires
Dry matter	76%	80%	85%
Total carbon content	56%	50%	50%
Fossil carbon fraction	36%	90%	0%
Oxidation factor in % of carbon input	58%	58%	58%

As IPCC guidelines do not account for open pit burning of IW/bonfires, the default oxidation factor for MSW was used. Dry matter of IW is an estimate.

8.5 Composting (6D)

Composting has been practiced for some years in Iceland, both domestically as well as municipally. Garden and Park waste has been collected from the Reykjavík capital area and composted according to the "Window method", where grass, tree crush and horse manure are mixed together. In some small municipalities there is an active composting program where most organic waste is collected and composted. Composting started in 1995 and a further emphasis is placed on composting as an option in waste treatment for the future by the opening of new composting facilities in Sauðárkrókur in 2007 and Eyjafjörður in Northern Iceland in 2009.

Activity data

Activity data are collected from local municipals by the Environment Agency of Iceland.

Emission factors

Choice of emission factor is in accordance with IPCC Tier 1 method.

Table 8.10 Emission factors

	Emission factors
CH_4	4 g CH_4/kg
N_2O	0.3 g N_2O/kg

*IPCC default values (2006 IPCC Guidelines for National Greenhouse Gas inventory, Table 4.1)

9 RECALCULATIONS AND IMPROVEMENTS

9.1 Overall description of recalculations

The Icelandic greenhouse gas emission inventory has in 2010 been recalculated to a minor extent (Table 9.1). All recalculations made are calculated for the entire time series 1990-2008. Recalculation for some components and sources have been made, to account for new knowledge and/or more accurate approximation of activity data and emission factors and to correct for some errors in the calculations. The figures reported in this submission are therefore consistent throughout the whole time series.

Table 9.1 Total recalculations in 2010 submission compared to 2009 submissions(without LULUCF). Unit: Gg CO_2 eq.

Year	Submission 2009	Current Submission 2010	% change 2009-2010
1990	3,400	3,415	0.4%
1995	3,173	3,204	1%
2000	3,730	3,766	1%
2005	3,694	3,727	0.9%
2006	4,236	4,263	0.6%
2007	4,482	4,508	0.6%

9.2 Specific description of the recalculation

9.2.1 Energy

9.2.1.1 Manufacturing industries and construction (1A2)

During this inventory cycle most of the calculation sheets were revised to facilitate quality procedures. During this work some minor errors in the calculations were discovered, regarding gases other than greenhouse gases.

9.2.1.2 Transport (1A3)

Iceland has changed the CO_2 emission factors for both gasoline and diesel oil following a recommendation by an ERT. Now, Iceland uses the default values as presented in the 1996 Guidelines. This has led to the differences in emission estimates that are presented in (Table 9.2).

Table 9.2 Recalculations results for road transport. Gg CO_2 equivalents

Year	Road transport (submission 2009)	Road transport (submission 2010)	Change in %
1990	517	529	2%
1995	548	561	2%
2000	620	633	2%
2005	786	800	2%
2006	901	914	1%
2007	934	946	1%

9.2.2 **Industry**

9.2.2.1 Cement Production (2A1)

Activity data for clinker production in 2002 was corrected. This resulted in lower CO_2 emissions that year, from 39.4 to 38.3 Gg.

9.2.2.2 Consumption of Halocarbons and SF_6 (2F)

Emissions of HFCs were revised as EA received new export data on HFC-134a to destruction from 2001 to 2007. Export was underestimated before and this change has led to a decrease of 2 – 5% in total HFC emissions in years concerned (Table 9.3).

Table 9.3 Recalculations results for HFC-134a Gg CO_2 equivalents

Year	Submission 2009	Current submission 2010	Change in %
2001	31.5	30.8	2%
2002	32.6	31.5	3%
2003	38.6	37.3	4%
2004	43.1	40.9	5%
2005	49.4	47.5	4%
2006	53.0	50.7	5%
2007	59.4	56.9	4%

9.2.3 **Agriculture**

9.2.3.1 Enteric fermentation

Enteric fermentation from cattle and sheep was moved from Tier 1 to Tier 2. Population statistics for those species were revised. This has led to the differences in emission estimates that are presented in Table 9.4.

Table 9.4 Recalculation results for enteric fermentation. Gg CO_2 equivalents.

Year	Cattle (submission 2009)	Cattle (submission 2010)	Change in %	Sheep (submission 2009)	Sheep (submission 2010)	Change in %
1990	117.7	76.5	-35%	128.9	158.7	23%
1995	108	78	-28%	107.7	132.8	23%
2000	103.3	71.4	-31%	109.4	153.1	40%
2005	94.3	64	-32%	106.9	128.5	20%
2006	98.1	66	-33%	107	127.8	19%
2007	100.7	68.4	-32%	106.8	127.7	20%

9.2.3.2 Manure management

The revision of population statistics for cattle and sheep as well as the changes in Nex for cattle and swine has led to changes in emissions estimates for manure management. These changes are shown in Table 9.5.

Table 9.5 Recalculation results for manure management. Gg CO_2 equivalents.

Year	submission 2009	submission 2010	Change in %
1990	58.5	54	-8%
1995	52.4	50.9	-3%
2000	50.7	50.1	-1%
2005	47.9	46.9	-2%
2006	49.8	48.2	-3%
2007	49.9	48.8	-2%

9.2.3.3 Emissions from Agricultural Soils – N_2O (4D)

The revision of population statistics for cattle and sheep, the changes in Nex for cattle and swine as well as the inclusion of cultivation of histosols has led to changes in emissions estimates for agricultural soils. These changes are shown in Table 9.6.

Table 9.6 Recalculation results for agricultural soils. Gg CO_2 equivalents.

Year	submission 2009	submission 2010	Change in %
1990	244	256.2	5%
1995	224.1	248.2	11%
2000	235.8	266.9	13%
2005	199.1	228.3	15%
2006	226.2	255.1	13%
2007	244.7	274.1	12%

9.2.4 **LULUCF**

9.2.4.1 Forest land

As described above the emission/removal estimate for forest land has been revised from previous submissions. The C-stock changes are based on direct stock measurements as in last year's submission but reviewed on basis of additional data. The restructuring of the data, due to changed conversion period, is implemented for the emission/removal estimate of all years prior to the inventory year. The estimate of changes in soil carbon in mineral soils in Afforestation 1-50 years old has great effects on the reported emission/removal. As result of this recalculation the total reported removal has increased from -80.04 Gg CO_2 eq for the year 2007 as reported in the 2009 submission to -122.47 Gg CO_2 eq in this year's submission or a 53 % increase in removal. Last year's submission showed 46% reduction in reported removal for the year 2006. These fluctuations in reported emission removal of the category reflect the development in available data and methodology applied for estimating this category.

9.2.4.2 Grassland

Drained land has previously been reported as aggregate number for all categories except forest land but is now reported separately for Grassland and Cropland. Also the method applied to estimate the area drained differ from the one used in previous submissions. Due to these changes the emission reported from "Wetland converted to Grassland" is recalculated for the years 1990-2007.

9.2.5 **Waste**

Minor changes in the chapter are due to recalculation on landfill emission.

9.2.5.1 Solid Waste Disposal on Land (6A)

Data on solid waste disposal on land were revised for 2006 and 2007 due to new and revised activity data and emissions. This was mainly due to revision of industrial waste, where larger part was recycled rather than placed on landfill as reported in previous submission. The relative amount of managed and unmanaged waste changed also as wastes are increasingly disposed of in managed landfills. This led to an overall minor decrease in emissions from landfills (Table 9.7)

Table 9.7 Recalculations of the Waste section in 2010 submission compared to 2009 submissions Gg CO_2 eq.

Year	Submission 2009	Submission 2010	% change
2006	213.4	213	0%
2007	228.0	226	-1%

Proportion of landfilled municipal solid waste is reported in the CRF reporter in the current submission, instead of as a proportion of Total (industrial and municipal solid waste) as was incorrectly reported in earlier submissions.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

10 KYOTO PROTOCOL – LULUCF

10.1 General Information

The Icelandic greenhouse gas emission inventory for the KP LULUCF is prepared by AUI on basis of information provided by IFS on ARD and SCSI on Revegetation. The general methods applied to estimate the sinks and sources reported are described in Chapter 7 of this report.

10.1.1 Definition of forest and any other criteria

Iceland's definitions of forest are identified as the following, in accordance with decision 16/CMP.1 adopted by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol.

Forest definitions are consistent with those historically reported to and subsequently published by the Food and Agriculture Organisation (FAO) of the United Nations, with the exception of tree height.

Definitions of forest as used by IFS
Minimum value for forest area: 0.5 ha
Minimum value for tree crown cover: 10%
Minimum value for tree height: 2 m

In the Global Forest Resources Assessment 2005 (coordinated by FAO), countries are requested to use a uniform forest definitions.

Criteria in forest definitions of the Marrakech Accord (MA), the UNEP Convention on Biological Diversity (CBD) and the Forest Resource Assessment (FAO/FRA) are listed in the table velow.

Parameters	MA	CBD	FAO/FRA
Minimum area (ha)	0.05-1.0	0.5	0.5
Minimum height (m)	2-5	5	5
Crown cover (%)	10-30	10	10
Strip width (m)			20

Iceland uses the suggested FAO definition, but instead of the suggested 5 m height minimum, Icelandic forests are defined as being at least 2 m in height. That is in agreement with the general perception in Iceland and current legitimate definitions. Only 10% of the native woodland does reach 5 m height. By widening the definition of forest, natural birch woodland can be included as an ARD activity under the Kyoto Protocol, hence promoting the use of native species in afforestation and prevent deforestation of the natural birch woodlands.

The functional definition of Forest land as it is applied under the KP – LULUCF is: All forested land, not belonging to Settlement, that is presently covered with trees or woody vegetation more than 2 m high, crown cover of a minimum 10% and at least 0.5 ha in continuous area with minimum width of 20 m. Land which currently falls below these thresholds but *in situ* will reach these thresholds at mature state is included.

10.1.2 **Elected activities under Article 3, paragraph 4**

Iceland elected Revegetation, defined in Paragraph 6 in the Annex to Decision 16/CMP.1 as "additional human activities related to changes in greenhouse gas by source and removals by sinks in the agricultural soils and the land-use change and forestry categories", defined by Article 3, paragraph 4 of the Kyoto Protocol.

Interpretation of elected activities under Article 3.4

Revegetation is defined in Paragraph 1(e) in the Annex to Decision 16/CMP.1 as "a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation".
Iceland interprets the definition of Revegetation as following, recalling the LULUCF-Good Practice Guidance:

- A direct human-induced activity to increase carbon stocks on eroding **or** eroded/desertified sites through the establishment of vegetation or the reinforcement of existing vegetation that covers a minimum area of 0.5 hectares and does not meet the definitions of afforestation or reforestation.

Hierarchy among the elected activities under Article 3.4

Revegetation is the only activity elected by Iceland under Article 3.4, therefore hierarchy among activities is not applicable.

10.1.3 **Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time**

Iceland has elected reporting method 1 to report land areas subject to Article 3.3 and Article 3.4 activities as described in LULUCF-Good Practice Guidance, page 4.24, section 4.2.2.2 Only one strata, Region 1 is defined covering all land areas in Iceland.

Article 3.3

In Region 1 afforestation since 1990 is estimated by the systematic sample of permanent plots (SSPP) in the NNFI of IFR. The plots of the cultivated forest and in the natural birch forest will be re-measured at five and ten years intervals respectively. Re-measurement of the cultivated forest will start 2010 but in 2015 for the natural birch forest. At each plot, the land use is assessed and compared to former land use. Reforestation has not been detected at the SSPP of the NNFI.

Although SSPP of NNFI will in the future detect deforestation, special deforestation inventories aimed on deforested areas are performed (See further description in Chapter 10.4).

Within Region 1 all cultivated forests and natural birch woodland are already mapped. Only SSPP which are within mapped area and adjacent buffer zone are visited. The results from the NNFI are used to determine the ratio of the mapped area meeting the definition of forest land. At the SSPP, data on C-pools is collected as described above (see Chapter 7.12). New land being afforested is recorded annually by IFR and consequently added to the mapped area forest land. The SSPP falling on these new area are then included in the NNFI.

Article 3.4

The SCSI is responsible for the National Inventory of Revegetation Activity (NIRA). As with the NNFI the whole country is defined as one region. Within Region 1 all known revegetation areas are mapped. The SSPP falling within these maps are visited in NIRA and precedence of activity determined (see below). At each SSPP visited, data on relevant C-pools is collected. The onset of activity is determined according to the existing records of SCSI. New areas of Revegetation activity are recorded by the SCSI and consequently mapped. The SSPP falling within these new areas are then included in NIRA.

The SSPP will be revisited at five years interval. The NIRA started in 2007 and estimation of changes in C-pools on revegetated land based on the data from NIRA will be available in 2013 submission as first SSPP will be revisited 2012. Presently the sinks and sources are estimated according to Tier 2 methods described in Chapter 7.14 of this report.

The NIRA was designed to detect changes in C-pools and area of revegetation activity since 1990. The estimation of revegetation activity in the base year and of relevant sinks and sources is based on same methods as described in Chapter 7.14 of this report. The maps of revegetation activity before 1990 are far less accurate than the maps of activity since 1990. To secure clear separation of activities before and since 1990 the SCSI is improving these maps both according to existing archives and direct mapping from remote sensing and on ground mapping. On basis of those maps the NIRA will be extended to include the revegetation activity before 1990.

10.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified.

Revegetation is the only Article 3.4 activity elected. Hierarchy among activities is thus irrelevant. Organized revegetation and land reclamation activities date back to 1907 when the Soil Conservation Service of Iceland (SCSI) was established. Initial efforts were focused on halting accelerated erosion and serious land degradation, both directly and indirectly. Direct efforts included seeding lymegrass (*Leymus* *arenarius*) and erecting fences to halt sand-encroachment, but indirect efforts included excluding grazing animals by fencing off degraded lands. Recordkeeping until 1990 was fragmented, emphasizing mostly on activities but less on their spatial extent. Activities since 1990 have better spatial documentation as aerial and satellite imagery has been used for boundary determination, and since 2002 most activities are recorded in real-time using GPS.

Data on post-1990 revegetation areas are kept in a SCSI database containing best available data on reclamation areas at any given time. One objective of initiating NIRA was to monitor changes in carbon stocks of revegetation area, using systematic sampling on predefined 1 x 1 km grid points. The grid was constructed by the Iceland Forestry Service (IFS) from a randomly chosen point of origin, and is used by them for their KP LULUCF reporting (Snorrason and Kjartansson 2004).

Layers containing land reclamation areas documented as active since 1990 are overlaid with the sampling grid in a GIS to preselect potential sampling points. They are later located in the field using land-survey grade GPS units. All points that fall undoubtedly within areas where land reclamation efforts have taken place are selected as sampling points. Points falling outside are either discarded or selected as controls.

Sampling takes place within a 10 x 10 m sampling plot, using the sampling point as the SW plot corner. Five 0.5 x 0.5 m subplots are randomly selected within the sampling plot for C-stock estimation in both vegetation and soils. The KP LULUCF sampling started in 2007. During the first three years of the program, 525 sampling points have been selected as potential sampling points. 145 have been discarded after site visits or are still undetermined, (28%), 339 been sampled (65%), and 41 (8%) have been identified as controls. Points were randomly selected from all parts of the country in 2007 and 2008. A different approach was used in 2009, as emphasize was put on three key areas, each representing different climatic zone but also having wide variety of land reclamation activities. As each of these three sites also has similar soils, they will give good information on carbon sequestration potential between activities and climate zones. Each sampling period is expected to last for five years. In the remaining two years, 2010 and 2011, same sampling strategy will be used as was used in the first two years. Resampling of the plots established in 2007 will start in 2012.

The 1 x 1 km sampling grid is also used to add sampling points from new reclamation areas to the NIRA database, following the same methodology as described above. Quantities of pre-1990 reclamation sites remains to be determined (see information on Article 3.4 below).

10.2 Land-related information

10.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

Maps of cultivated forest and natural birch woodland do exist. Although they can be used to locate forests, they are not precise and overestimate area of cultivated forest. On the other hand they are used with an external buffer as a population for systematic sample of permanent plots. The permanent plots are used to estimate the area of both cultivated forest and natural birch woodlands. The area of afforestation since 1990 and accordingly falling under Article 3.3 is determined on basis of stand age within the sample plots. New areas afforested are added to the population for the SSPP annually and new sample plots falling within these areas are included in the forest inventory.

10.2.2 Methodology used to develop the land transition matrix

As this is the first year of reporting KP_LULUCF land transition matrix is not applicable.

10.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Maps of cultivated forest and natural birch woodland do exist but it is not possible to isolate from these maps land subjected to ARD. The proportion of the area mapped identified as cultivated forest is determined through the inspection of IFR on the systematic sampling plots of the NNFI. Geographical locations of ARD can partially be identified by geographical distribution of the systematic sample plots identified as ARD. On the other hand deforestation is mapped separately and will be fully identifiable geographically.

The land subjected to Revegetation is mapped and identified in IGLUD. The area reported as Revegetation since 1990 is in present submission larger than the area mapped as such in IGLUD. The present area estimate of revegetation activities since 1990 is an accumulation of annual estimates for revegetation activity. Not all of these activities have been mapped and are accordingly not included in IGLUD. The SCSI is running the NIRA based on systematic sampling of plots within the mapped areas. The results from the NIRA were not available for this year’s submission, but first estimates based on the NIRA data will be included in next year’s report. Only mapped areas are included in the NIRA and new areas will be mapped prior to reporting.

10.3 Activity-specific information

10.3.1 Methods for carbon stock change and GHG emission and removal estimates

10.3.1.1 Description of the methodologies and the underlying assumptions used

Article 3.3

Carbon stocks changes in living biomass in cultivated forest are based on measurements of sampling plots in the NNFI. At each plot parameters to calculate above ground biomass are determined including tree height, diameter and number of trees inside the plot area etc. These parameters are then used to calculate the living biomass of trees according to species specific single tree biomass functions (Snorrason and Einarsson 2006). Wood removal after thinning or clear cutting has not been detected in the NNFI on afforestation areas since 1990. Carbon stock losses in the living woody biomass are therefore reported as not occurring.

Changes of carbon stock in mineral soil of Grassland converted to forest land are based on Tier 2 methodology applying country specific EF. The EF is based on soil sampling from chrono-sequential research (Bjarnadóttir 2009) showing increasing SOC in 0-10 cm depth layer with stand age up to 50 years old stands. No changes in SOC in 10-30 cm depth layer were observed. The results of this study are assumed to apply for afforestation 1-50 years old on mineral soils. For the organic soils Tier 1 methodology is applied using default EF. The area of organic soils is determined on basis of the NNFI sampling plots.

Article 3.4

The changes in carbon stocks at revegetation sites are estimated on basis of country specific EF covering all carbon pools. The current EF is estimated from a study on carbon sequestration in revegetation sites (Arnalds et al. 1999; Aradóttir et al. 2000; Arnalds et al. 2000). Built on the same studies the EF was assumed to be 10% due to living ground biomass and dead organic matter and 90% to soil.

10.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Article 3.3

The two carbon pools that are omitted under article 3.3 as whole in this year's submission are the carbon pool of dead wood and the carbon pool of litter. Measurements of dead wood are performed on the field plots in the NNFI and dead wood is defined in similar way as done in NFI's in other European countries (Snorrason 2010). Only after revisiting the plots in five to ten years it is possible to estimate changes in the dead wood pool. It can be stated that dead wood on Afforestation since 1990 was very rare in the first NFI conducted in the year's 2005-2009 which can be explained with young age of the these afforestation sites.

Carbon stock samples of litter are collected on field plots under the field measurement in NNFI. As for the dead wood, carbon stock changes in litter will also be available from NNFI data when sampling plots will be revisited in the next five to ten years. In the meantime results from two separate researches of carbon stock change will be used to estimate carbon stock change in litter. (Snorrason et al. 2000; Snorrason et al. 2003; Sigurdsson et al. 2005). They did show significant and considerable increase in the carbon stock of the litter for afforestation up to 50 years old for different tree species on different sites. Calculation on the effect of the C-stock increase of the litter for afforestation since 1990 was not finished in time to be incorporated in this year's submission but will be added in the next year's submission.

Changes in other carbon pools are currently only partially omitted. Afforestation of natural birch forest on abandoned grazing land is currently omitted for all carbon pools as crucial mapping data for these afforestation sites are still lacking. Mapping of these afforestation sites will start in the summer of 2010.

Losses of aboveground biomass of trees because of wood removal after thinning or clear cutting are omitted as wood removal was not detected for afforestation since 1990 in the first NFI. Wood removal was only detected on older afforestation sites. These sources will be estimated when they are detected when revisiting field plots in future NFI's after thinning with wood removal will start on these sites.

Carbon stock samples of above ground biomass of other vegetation than trees are collected on field plots under the field measurement in NNFI. Estimate of carbon stock changes in aboveground biomass of other vegetation than trees will be available from NNFI data when sampling plots will be revisited in the next five to ten years.

Change in the carbon stock of other vegetation than trees is omitted in this year's submission. A research project where carbon stock in other vegetation than trees was measured on afforestation sites of different ages with larch did show very low increase C-stock 50 years after afforestation although the variation inside this period where considerable (Sigurdsson et al. 2005).

Article 3.4

Losses in Revegetation are not detected specifically. The losses are assumed to be reflected in the changes in the C-pools estimates. Potential losses include losses in revegetated area, due to changes in land use. Losses in C-pools through grazing, biomass burning and erosion are also recognized as potential. These losses are expected to be detected in NIRA, but until then not specifically included.

10.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

No attempt is made to factor out indirect or natural GHG removals/emissions. This applies both for ARD and Revegetation.

10.3.1.4 Changes in data and methods since the previous submission (recalculations)

KP- LULUCF emission/removals have not been reported earlier and consequently no changes in method or data.

10.3.1.5 Uncertainty estimates

An error estimate is available for the area of afforestation of cultivated forest. The area of afforestation since 1990 is estimated to 28.46 kha (±1.68 kha 95% CL)
Uncertainty estimates for revegetation are not available yet but will be included in next year submission

10.3.1.6 Information on other methodological issues

10.3.1.7 The year of the onset of an activity, if after 2008

Not applicable.

10.4 Article 3.3

10.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

The age of afforestation is estimated in field on the sample plots of the NFI. For cultivated forest they are mostly plantations. Minority are direct seeded or self seedlings originated from cultivated forest. As mentioned before afforestation of natural birch forest is still missing but will in the future also be estimated in field. They are self-seeded areas in the neighbourhood of older forest areas. In both cases land use have been changed from other land use to forest with afforestation by planting and/or by total protection or drastic reduction of grazing of domestic animals. These actions are considered direct human-induced.

10.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Deforestation is estimated by special inventory where the change in the area of forest where deforestation has been reported is estimated by GPS delineation of a new border between forest and the new land use which is dominantly settlements (new power lines, roads or buildings). Major forest disturbances will be detected in the NNFI but local forest disturbances (wildfires etc) will be handled with special inventory as done for deforestation.

10.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

The only human induced forest degradation occurring is when trees have to give a way for summer houses and road system to summer houses. There the forest removed are under the minimum area of 0.5 ha or 20 m with. No direct estimate of the effect of decrease of the C-stock is done but the permanent sample plot system of the NFI will detect significant forest degradation.

10.5 Article 3.4

10.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

All the revegetation activity included under Article 3.4 is included on bases of SCSI activity records. No area not recorded by SCSI as revegetation activity is included.

10.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

The removal recorded due to Revegetation in base year is estimated from SCSI archives on revegetation prior to 1990. All land revegetated before 1990 is included in the estimate. The estimate of changes in C-pools is according to Tier 2 methods as described in chapter 7.14.

10.5.3 Information relating to Forest Management

Forest management is not elected.

10.6 Other information

10.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

Of the three categories reported under Article 3.3 and Article 3.4 both Revegetation and Afforestation and Reforestation are recognized as key categories Deforestation was detected as not occurring in 2008.

Table 10.1 Key categories of KP reporting

Category	Absolute Emission/Removal Gg CO2 eq	Level %	Cumulative level %	Key source/sink
Revegetation	548.49	84.4	84.4	x
Afforestation and Reforestation	101.18	15.6	100	x
Deforestation	NO			
Total	**649.67**			

11 INFORMATION ON ACCOUNTING OF KYOTO UNITS

11.1 Background information

The Icelandic Greenhouse Gas Registry is maintained by the Environment Agency. A description of the Registry System is presented in Chapter 13.

Article 3 in part I 'General reporting instruction', to Annex 'Standard electronic format for reporting of information on Kyoto Protocol units', of decision 14/CMP.1 says: … "each Annex I Party shall submit the SEF in the year following the calendar year in which the Party first transferred or acquired Kyoto Protocol units". Iceland did not submit the SEF tables, as Iceland has not yet transferred or acquired any Kyoto Protocol units.

11.2 Summary of information reported in the SEF tables

Iceland has not reported information on its accounting of Kyoto Protocol units in the required SEF tables, as required by decisions 15/CMP.1 and 14/CMP.1 as Iceland has not issued its assigned amount or transferred any Kyoto Protocol units.

11.3 Discrepancies and notifications

No discrepancies and notifications have occurred as the national registry is not connected with the production environment of the ITL in May 2010 and Iceland has not issued its assigned amount or transferred any Kyoto Protocol units.

11.4 Publicly accessible information

No public information is available as the national registry is not connected with the production environment of the ITL.

11.5 Calculation of the commitment period reserve (CPR)

The Annex to Decision 11/CMP.1 specifies that: 'each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest'.

Therefore Iceland's commitment period reserve is calculated as, either:

90% of Iceland's assigned amount

= 0.9 × 18,527,859 tonnes CO_2 equivalent

= 16,675,073 tonnes CO_2 equivalent.

or,

100% of 5 × (the national total in the most recently reviewed inventory)

= 5 × 4,880,097 tonnes CO_2 equivalent

= 24,400,483 tonnes CO_2 equivalent

This means Iceland’s Commitment Period Reserve is 16,675,073 tonnes CO_2 equivalent, calculated as 90% of Iceland’s assigned amount.

11.6 KP-LULUCF accounting

Iceland intends to account for Article 3.3 and 3.4 LULUCF activities for the entire commitment period. Removals from Article 3.3 amounted to 102.346 Gg and from Article 3.4 to 268.913 in 2008. This would allow issuance of 371,259 RMUs.

12 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes have been made regarding the national system since last submission.

13 INFORMATION ON CHANGES IN NATIONAL REGISTRY

As Iceland is part of the EU ETS a CITL connection is planned in the near future. In May 2010 the Icelandic registry did go live with the ITL as non-operational registry during the period prior to the connection to the CITL, since CITL cannot recognize transactions made only within the ITL.

No changes have been made to the registry since last NIR submission. A full description of the registry was given in Iceland's Initial Report. Some changes have been made since then. The current status of the registry is presented below.

13.1 Description of the Registry System

13.1.1 Implementing and running the registry system

The Environment Agency of Iceland is responsible for the implementation and operation of Iceland‘s National Registry under the Kyoto Protocol. The software used for the Icelandic National Registry is GRETA (Greenhouse gases Registry for Emissions Trading Arrangements) The IT software supplier of GRETA is SFW.

Contact details of registry administrators

Institution:	Environment Agency
Contact:	Department for Environmental Quality
Address:	Sudurlandsbraut 24 IS-108 Reykjavík, Iceland
Telephone:	+354 591 2000
Fax:	+354 591 2020
Registry System Administrators:	Birna Hallsdóttir (birna@umhverfisstofnun.is) Sigurður Finnsson (sigurdurb@umhverfisstofnun.is)

13.1.2 Technical description

This technical description of the Icelandic National Registry is presented in accordance with the reporting requirements in Annex II under decision 15/CMP.1.

13.1.3 Consolidated registry systems

The Icelandic National Registry is a standalone registry; it is not operated together in a consolidated form with the registries of other nations.

13.1.4 Compliance with ITL data exchange standards

The GRETA registry software was originally developed for use in the European Union Greenhouse Gas Trading Scheme (EU ETS) which requires the registry to be compliant with the UN Data Exchange Standards (DES) for communication with UN‘s International Transaction Log (ITL).

The software implements all UN DES. The registry communicates with ITL using XML messages and web-services as specified in the UN DES. These methods are used to perform issuance, conversion, external transfer, cancellation, retirement and reconciliation processes.

13.1.5 **Strategies employed to minimize discrepancies**

The Icelandic national registry fulfils all required processes to minimize discrepancies in issuance, transactions, cancellation and retirement of ERUs, CERs, AAUs or RMUs. UN DES specifications are followed at every step of the transactions to minimize risks of inconsistent data in the registry database and ITL. Before forwarding requests to ITL the registry validates data entries against a list of checks performed by ITL (see Annex E of UN DES). A transaction is not finalized until the transaction is registered on both registry servers. The transaction is cancelled if ITL sends an error code. The registry administrator has to contact the ITL administrator for instructions if the registry fails to terminate the transaction. It can be necessary to perform manual corrections in the registry database by the registry administrator.

Each unit is marked with unique codes internally in the registry database. This prevents units to be used in more than one transaction until confirmation of successful transaction has been received by ITL and the transaction is completed.

When sending a message, the registry waits for an acknowledgement of the message being received by ITL before completing submission of the message. If no acknowledgement is received after number of retries, the registry terminates the submissions and performs roll-back on any changes possibly made to the involved unit blocks.

Upon receiving the 24 hour clean-up message from ITL, the registry rolls back any pending transactions including units that were involved. This prevents discrepancies of unit blocks between the registry and ITL.

If all automatic roll-back functions of the registry fail to prevent discrepancies with ITL, a number of manual intervention functions exist in the registry software for the administrator to fix the problem. In worst cases a SQL script will be generated to directly fix problems in the registry SQL database.

After any problem, a reconciliation process is run to confirm that both the registry and ITL agree on all relevant data.

13.1.6 **Database and registry server specifications**

The registry software runs on two separate servers all running as VMware virtual machines on blade servers. The servers run Microsoft Windows 2003.

Server 1: The SQL server
The database server is Microsoft SQL Server 2005 (32-bit) standard edition. The SQL server runs on a separate virtual server.

Server 2: The business logic layer and web access for registry system administrators
A single virtual server runs both the business logic layer (a web service) which handles requests to and from the database server and the registry system administrator access (web interface). The server runs .NET 1.1 runtime and IIS 6.

13.1.7 Disaster prevention and recovery

The registry server is located at a dedicated IT hosting company in Iceland named Skyrr. The server is stored in a fire-proof, temperature controlled room with sensitive fire-detection systems. Access to the server room is only allowed by authorized people and all access is logged.

A daily full backup is taken of the servers with a retention period of 5 weeks.
To mitigate possible data loss in a disaster scenario, backups are sent to an off-site data centre (located 12 km away from the main server room). Critical software patches are applied when they become available. In general 2 working days are needed to get the registry up and running in case of failure.

13.1.8 Testing of the Icelandic national registry

The current version of the GRETA registry system software has already proved its functionality against CITL (EU´s Community Independent Transaction Log). Testing of GRETA against CITL has been done in co-operation of the members of the GRETA working group (GRETA WG) and the current developers of the software.

GRETA WG performs thorough testing of the GRETA registry software in cooperation with the GRETA developers.

13.1.9 Security of the Icelandic National Registry

Administrators and users are granted access through a web interface with usernames and passwords. Digital certificates are used to increase the strength of user authentication.

Access permissions are defined for each user which determines his access to the registry system. This prevents any unauthorized access to restricted procedures. Audit logs are used to track actions.

No direct manipulations of the database are possible through the web-services. Changing the database through the web user-interface is only possible by running predefined procedures. This decreases greatly the risk of intentional or unintentional attacks on the integrity of the database through the web interface.

To minimize risks of incorrect actions due to user errors, the registry uses the following checks before submitting user input for processing:

- Validates all user input before processing.
- Users are asked for confirmation of their input.
- Internal approval process is implemented for secondary approval before submitting details to ITL.

13.1.10 **Public information accessible through the web page**

The registry software will at least allow public access to reports as required under 5/CMP.1, 13/CMP.1 and 14/CMP.1. These reports will be easily accessible through the web-based home page of the registry system.

13.1.11 **Webpage of the registry system**

The Icelandic national registry system will be accessible through the web address: http://co2.ust.is

14 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Actions	Implementation
The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities, in pursuit of the objective of the Convention	Planning of economic instruments in Iceland, *inter alia* for limiting emissions in the greenhouse gas emitting sectors is subject to different methodologies. These involve feasibility and efficiency and consideration of national and international circumstances.
Removing subsidies associated with the use of environmentally unsound and unsafe technologies	Subsidies associated with the use of environmentally unsound and unsafe technologies have not been identified in Iceland
Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end	Icelandic research institutes and technological development centres have not been engaged in development of non-energy uses of fossil fuels
Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort	Icelandic researchers cooperate with French and U.S. colleagues on an experimental project (CarbFix) that is under way at the Hellisheiði geothermal plant, injecting CO_2 captured in geothermal steam back into the basaltic rock underground. The aim of the Carbfix Project is to study the feasibility of sequestering the greenhouse-gas carbon dioxide into basaltic bedrock and store it there permanently as a mineral. The project's implications for the fight against global warming may be considerable, since basaltic bedrock susceptive of CO_2 injections are widely found on the planet and CO_2 capture-and-storage and mineralization in basaltic rock is not confined to geothermal emissions or areas
Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil	The Government of Iceland has supported developing countries in the area of sustainable utilization of natural resources through its administration of the United Nations University

fuels, taking into consideration the need to improve the environmental efficiency of these activities	Geothermal Training Program. The Geothermal Training Program has operated over thirty years, building up expertise in the utilization of geothermal energy, by training more than 400 experts from over 40 countries. The program provides their graduating fellows with the opportunity to enter MSc and PhD programmes with Icelandic universities. Iceland will continue its support for geothermal projects in developing countries with geothermal resources, which can be utilized to decrease their dependency on fossil fuels for economic development.
Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies	Iceland does not have support activities in this field

15 OTHER INFORMATION

16 REFERENCES

Althing (2007), Lög um losun gróðurhúsalofttegunda nr. 65. Lagasafn. Íslensk lög 15. maí 2009. Útgáfa 136b.

Aradóttir, Á. L., K. Svavarsdóttir, T. H. Jónsson and G. Guðbergsson (2000). "Carbon accumulation in vegetation and soils
by reclamation of degraded areas." Iclandic Agricultural Science **13**: 99-113.

Ármannsson, H., Friðriksson, Þ., Kristjánsson, B. (2005). "CO2 emissions from geothermal power plants and natural geothermal activity in Iceland". Geothermics.

Arnalds, Ó., Á. L. Aradóttir, A. Snorrason, G. Gudbergsson, T. H. Jónsson and A. M. Ágústsdóttir (1999). Organic carbon sequestration by restoration of severely degraded areas in Iceland. Iceland, Agricultural Research Institute: 1-19.

Arnalds, Ó., G. Guðbergsson and J. Guðmundsson (2000). "Carbon sequestration and reclamation of severely degraded soils in Iceland." Búvísindi 13: 87-97.

Arnalds, O. and E. Gretarsson (2001). Soil Map of Iceland. 2nd edition. Reykjavík, Agricultural Research Institute.

Arnalds, Ó., E.F. Thorarinsdóttir, S. Metúsalemsson, Á. Jónsson, E. Gretarsson and A. Árnason. (2001). Soil erosion in Iceland. Reykjavík, Soil Conservation Service, Agricultural Research Institute.

Arnalds, O., A. L. Aradottir and G. Gudbergsson (2002). Organic Carbon Sequestration by Restoration of Severely Degraded Areas in Iceland. Agricultural Practices and Policies for Carbon Sequestration in Soil. R. L. J.M. Kimble, R.E. Follett, Lewis Publisher: 267-280.

Arnalds, Ó., Hlynur Óskarsson, Fanney Ósk Gísladóttir and E. Grétarsson (2009). Íslenskt Jarðvegskort Landbúnaðarháskóli Íslands.

Arnalds, Ó. and H. Óskarsson (2009). "Íslenskt Jarðvegskort." Náttúrufræðingurinn **78**(3-4): 107-121.

Auðunsson, G.A (2002). Hegðun og samsetning fráveituvatns í Skolpu 2000-2001 Icelandic Fisheries Laboratories Report Summary 27/03/2002.

Bjarnadóttir, B. (2009). Carbon stocks and fluxes in a young Siberian larch (Larix sibirica) plantation in Iceland. Department of Physical Geography and Ecosystem Analysis. Lund, Lund University. **Ph.D:** 171.

Bossard, M., Feranec, J., and Otahel, J.(2000). CORINE land cover technical guide – Addendum 2000, European Environment Agency, CopenhagenNo 40, 10.

Bændasamtök-Íslands (2010). Hagtölur landbúaðarins, Bændasamtök Íslands.

Damgaard Poulsen H. (2009) Normtal for husdyrgödning.
http://www.agrsci.dk/var/agrsci/storage/original/application/6ad0435ef70c7cb3b7c30f15b406c0e3

EA (2002). Starfsreglur um góða búskaparhætti (Codes of good agricultural practice). Starfshópur um meðferð úrgangs frá landbúnaði: 17. http://www.ust.is/media/fraedsluefni/buskaparhaettir.pdf

EA (2003). Landfill Gas Formation in Iceland. A study on Landill Gas Formation in landfills in Iceland, in relation to the iplementation of the Landfill Directive into the national act. http://www.ust.is/media/fraedsluefni/LFG_formation_in_Iceland_final_2003.pdf

EA (2004). Landsáætlun um meðhöndlun úrgangs 2004 - 2016 (National waste treatment plan 2004 - 2016). Environment Agency of Iceland: 46.

EA (2004). Report to the EFTA Surveillance Authority regarding the implementation of Directive 92/271/EU on the treatment of wastewater from built-up areas. Environmental and Food Agency of Iceland.

EA (2007). Iceland's Initial Report under the Kyoto Protocol. http://unfccc.int/files/national_reports/initial_reports_under_the_kyoto_protocol/application/msword/initial_report_-_iceland.doc

EA (2007), Quality Assurance and Quality Control Plan for the Icelandic Greenhouse Gas Inventory.
http://www.ust.is/media/fraedsluefni/pdf-skjol//Iceland_QAQC_plan.pdf

Energy in Iceland: Historic Perspective, Present Status, Future Outlook (2004). National Energy Authority and Ministries of Industry and Commerce.

Friðriksson et al (2005). "CO2 emissions and heat flow through soil, fumaroles, and steam heated mud pools at the Reykjanes geothermal area, SW Iceland". In preparation for Applied Geochemistry.

Gísladóttir, F. Ó., Metúsalemsson, S., and Óskarsson, H. (2007). Áhrifasvæði skurða: Greining með fjarkönnunaraðferðum, Fræðaþing landbúnaðarins, Reykjavík, 371-376,

Gísladóttir, F. Ó., Guðmundsson, J., and Áskelsdóttir, S. (2009) Íslenskt skurðakort og greining á þéttleika skurða., Fræðaþing Landbúnaðarins.

Grétarsdóttir, J. and J. Guðmundsson (2007). Skammtímaáhrif sinubruna á Mýrum 2006 á gróðurfar og uppskeru. Fræðaþing landbúnaðarins, Reykjavík.

Gudmundsson, J. (2009). Vísinda og tæknileg lokaskýrsla:Verkefni: Losun hláturgass og annarra gróðurhúsalofttegunda úr lífrænum jarðvegi við mismunandi landnotkun., Lbhi: 11

Gudmundsson, J. and H. Óskarsson (2010). "Carbon dioxide Fluxes of upland terrestrial ecosystems in West Iceland." In prep.

Guðmundsson, J., F. Ó. Gísladóttir and S. H. Brink (in prep). Description of methods and definitions of land use classes used in the Icelandic Land Use Database.
Gunnarsson, E. (2009). "Skógræktarárið 2008." Skógræktarárið 2008 **2009**(2): 90-95.

Hanne Damgaard Poulsen (2009): Normtal for husdyrgødning – 2009, 35 sider. http://www.agrsci.dk/ny_navigation/institutter/institut_for_husdyrbiologi_og_sundhed/husdyrernaering_og_miljoe/normtal

Halldorsson, G., Agustdottir, AM., Bau, A., Thorarenssen J., Thorsson, J. & Svavarsdottir K (2009). A national inventory of carbon stocks in revegatation areas in Iceland (in prep.)

Hermannsson, J. (1993). Kornrækt á Íslandi. Ráðunautafundur 1993, Reykjavík, RALA.

Icelandic Association of Farmers, Agricultural Genetic Resources Committee, and Nordic Gene Bank for Domestic Animals (2004). Icelandic Livestock Breeds, ISBN 9979-885-02

Icelandic Nutrition Council (2002). The Diet of Icelanders. Dietary Survey of the Icelandic Nutrition Council 2002. Main findings.

Inga Þórsdóttir, Ingibjörg Gunnarsdóttir (2006). The Diet of Icelandic 9- and 15-year-old children and adolescents. Dietary Survey of Unit for Nutrition Research 2002-2003.

IPCC (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 1 – 3. Intergovernmental Panel on Climate Change.

IPCC (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change.

IPCC, Ed. (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry, IGES.

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories,. B. L. Prepared by the National Greenhouse Gas Inventories Programme. Eggleston H.S., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

Jóhannesson, B. (1998) Íslenskur jarðvegur, Rannsóknastofnun landbúnaðarins, Reykjavík.

Jónsson, J. (1968) Ræktun landsins, in: Bættir eru bænda hættir: landbúnaðurinn, saga hans og þróun Bókaútgáfan Þorri, 30-50.

Landsvirkjun, Landsvirkjun´s history. WWW.lv./ENcategory.asp?catID=465

Landmælingar_Íslands (1943). Herforingjaráðskort.

Kamsma & Meyles (2003). Landfill Gas Formation in Iceland. Environmental and Food Agency of Iceland: 37

Magnússon, B. ó., B. H. Barkarson, B. E. Guðleifsson, B. P. Maronsson, S. Heiðmarsson, G. A. Guðmundsson, S. H. Magnússon and S. r. Jónsdóttir (2006). Vöktun á ástandi og líffræðilegri fjölbreytni úthaga 2005. Fræðaþing Landbúnaðarins, Reykjavík.

Maljanen, M., B. D. Sigurdsson, J. Gudmundsson, H. Óskarsson, J. T. Huttunen and P. J. Martikainen (2010). "Land-use and greenhouse gas balances of peatlands in the Nordic countries – present knowledge and gaps." Biogeosciences Discuss., 6, 6271-6338, 2009
www.biogeosciences-discuss.net/6/6271/2009/

Ministry for the Environment (2007), Climate Change Strategy. http://eng.umhverfisraduneyti.is/media/PDF_skrar/Stefnumorkun_i_loftslagsmalum_en.pdf

Ministry for the Environment (2007). Protection and restoration of Icelandic birch forests. Ministry for the Environment, Reykjavik, 19 p.

National Energy Forecast Committee (2009). Eldsneytisnotkun Íslendinga eftir notkunarflokkum, innlend notkun. Fuel use in Iceland per type, domestic use. (Available on the committee’s website: http://orkuspa.is/eldsneyti/Innlend.PDF)

Náttúrufræðistofnun_Íslands (2005). Ársskýrsla 2005 (annual report). Reykjavík, Náttúrufræðistofnun Íslands: 42.

Norwgian Pollution Control Authority (2009). National Inventory Report 2009.

Norwgian Pollution Control Authority (2007). Revised National Inventory Report 2007.

Óskarsson, H. (1998). Wetland draining in Western Iceland. Icelandic Wetlands: exploitation and conservation. J. S. Olafsson. Reykjavík, University of Iceland Press.: 121-129.

Óskarsson, H., O. Arnalds, J. Gudmundsson and G. Gudbergsson (2004). "Organic carbon in Icelandic Andosols: geographical variation and impact of erosion." CATENA 56(1-3): 225-238.

Óskarsson, H. and J. Guðmundsson (2008). Gróðurhúsaáhrif uppistöðulóna; Rannsóknir við Gilsárlón 2003-2006, Landsvirkjun LV-2008/028, 142.

Óskarsson, M. and Eggertsson, M. (1991). Áburðafræði (Fertilisers). Búnaðarfélag Íslands: 135
Reykjavíkurborg (2008). Áætluð losun gróðurhúsalofttegunda frá bílaumferð í Reykjavík. Samantekt fyrir árin 1999-2007 með samanburði við 1990.

Road Traffic directorate (2009). http//www.us.is

SFT, SN (2004). National Inventory Report 2004 – Norway. Norwegian Pollution Control Authority & Statistics Norway: 176.

Sigurdsson, B. D., B. Magnusson, A. Elmarsdottir and B. Bjarnadottir (2005). "Biomass and composition of understory vegetation and the forest floor carbon stock across Siberian larch and mountain birch chronosequences in Iceland." Annals of Forest Science **62**(8): 881-888.

Sigurðsson, B. D., Á. Elmarsdóttir, B. Bjarnadóttir and B. ó. Magnússson (2008). Mælingar á kolefnisbindingu mismunandi skógargerða. Fræðaþing landbúnaðarins.

Sigurðsson, B. D. and A. Snorrason (2000). "Carbon sequestration by afforestation and revegetation as a means of limiting net-CO2 emissions in Iceland." Biotechnol. Agron. Soc. Environ. **4**(4): 303-307.

Snorrason, A. (2010a). Iceland. National Forest Inventories - Pathways for Common Reporting. E. Tomppo, T. Gschwantner, M. Lawrence and R. E. McRoberts, Springer**:** 612.

Snorrason, A. (in prep). "Methodology of carbon accounting and other data analysis and aggregations concerning forest and woodland in Iceland for the reporting year of 2007 and 2008" Rit Mógilsár Rannsóknastöðvar skógræktar. Nr. 23/2010. (In preparation).

Snorrason, A. and B. Kjartansson. (2004). "Íslensk skógarúttekt. Verkefni um landssúttekt á skóglendum á Íslandi. Kynning og fyrstu niðurstöður. (Islandic National Inventory. Project on inventory of forests in Iceland. Presentation and First Results)." Skógræktarritið(2): 101-108 (In Icelandic).

Snorrason, A., B. D. Sigurðsson, G. Guðbergsson, K.Svavarsdóttir and Þ.J.Jónsson (2003). "Carbon sequestration in forest plantations in Iceland." Búvísindi (Icel. Agr. Sci.) **15**(02): 81-93.

Statistical Yearbook of Iceland, 2007 (Statistics Iceland).

Sveinsson, Th. (1998) Næringarefnabókhald fyrir kúabú. Ráðunautafundur: 124-140 (in Icelandic).

The Environment Agency of Iceland (2007) Grænt bókhald, http://ust.is/Adofinni/starfsleyfi/graentbokhald/

Traustason, B. and A. Snorrason (2008). Stærð Skóglendis á Íslandi byggt á CORINE flokkun. Fræðaþing Landbúnaðarins 2008, Reykjavík.

United Nations (2002), Report of the Conference of the Parties on its Seventh Session, Held at Marrakesh From 29 October to 10 November 2001. Addendum. Part two: Action Taken by the Conference of the Parties. Volume I : 68.

UNFCCC secretariat (2009). "Report of the individual review of the greenhouse gas inventory of Iceland submitted in the year 2009 (in-country review) UNFCCC/WEB/IRI/2004/ISL (available on the secretariat web site http://unfccc.int/documentation/documents/advanced_search/items/3594.php?rec=j&priref=600005115#beg

UNFCCC (2010). Report of the individual review of the annual submission of Iceland submitted in 2009*. FCCC/ARR/2009/ISL, UNFCCC.

UNFCCC secretariat. "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories" (available on the secretariat web site http://unfccc.int/resource/docs/cop5/07.pdf)

U.S. Department of Energy and the U.S. Environmental Protection Agency (2000). "Carbon Dioxide Emissions from the Generation of Electric Power in the United States" http://tonto.eia.doe.gov/ftproot/environment/co2emiss00.pdf

http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php. Revised National Inventory Report 2007, Norway.

http://unfccc.int/resource/docs/2008/irr/isl.pdf. Report of the Review of the Initial Report of Iceland

Þórarinsson: Þjóðin lifði en skógurinn dó (1974) , Ársrit Skógræktarfélags Íslands, 41, 13. (Thorarinsson, Th., 1974: The nation survived but the forest died. Yearb. Icel. For. Soc. 1974, 16-29 (in Icelandic with English summary).

Þóroddur Sveinsson. Næringarefnabókhald fyrir kúabú (1998). Ráðunautafundur 1998; 124-140 (In Icelandic)

ANNEX I: 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 for 2007, Table A2 the level assessment of the key source analysis for 1990 and Table A3 the trend assessment of the key source analysis.

Table A1. Key source analysis – level assessment 2007

			Current year estimate non-LULUCF	Current year estimate LULUCF	Current year estimate absolute value	Level assessment without LULUCF	Cumulative total of column H	Level assessment with LULUCF	Cumulative total of column j
			4824	1683	7874	1		1	
5.C.2.3	wetlands converted to grassland	CO2		1353	1353	0.00	0.00	0.17	0.17
2.C.3	aluminium	CO2	1168		1168	0.24	0.24	0.15	0.32
5.B.2	Cropland	co2		997	997	0.00	0.24	0.13	0.45
1.AA.3b	road transport	CO2	851		851	0.18	0.42	0.11	0.55
5.C.2.5	other land converted to grassland, revegeta	CO2		-548	548	0.00	0.42	0.07	0.62
1.AA.4c	fishing	CO2	517		517	0.11	0.53	0.07	0.69
2.C.3	aluminium	PFC	349		349	0.07	0.60	0.04	0.73
1.AA.2	manufacturing industry and construction	CO2	343		343	0.07	0.67	0.04	0.78
2.C.2	ferroalloys	CO2	339		339	0.07	0.74	0.04	0.82
6.A	solid waste disposal on land	CH4	196		196	0.04	0.78	0.02	0.85
1.B.2	geothermal energy	CO2	185		185	0.04	0.82	0.02	0.87
5.A	forest land	CO2		-135	135	0.00	0.82	0.02	0.89
4.D.1	direct soil emissions	N2O	133		133	0.03	0.85	0.02	0.90
4.A.3	enteric fermentation, sheep	CH4	129		129	0.03	0.87	0.02	0.92
4.D.2	indirect soil emissions	N2O	108		108	0.02	0.90	0.01	0.93
1.AA.3a/d	transport	CO2	81		81	0.02	0.91	0.01	0.94
4.A.1	enteric fermentation, cattle	CH4	70		70	0.01	0.93	0.01	0.95
2.F	consumption of halocarbons and SF6	HFC	67		67	0.01	0.94	0.01	0.96
2.A	Mineral production	CO2	63		63	0.01	0.95	0.01	0.97

Table A2. Key source analysis – level assessment 1990

			current year estimate non-LULUCF	current year estimate LULUCF	Current year estimate absolute value	level assessment without LULUCF	cumulative total of column H	level assessment with LULUCF	cumulative total of column j
	Level		3321	2185	6108	1		1	
5.C.2.3	wetlands converted to grassland	CO2		1478	1478	0.00	0.00	0.24	0.24
5.B.2	Cropland	co2		992	992	0.00	0.00	0.16	0.40
1.AA.4c	fishing	CO2	655		655	0.20	0.20	0.11	0.51
1.AA.3b	road transport	CO2	521		521	0.16	0.35	0.09	0.60
2.C.3	aluminium	PFC	420		420	0.13	0.48	0.07	0.67
1.AA.2	manufacturing industry and construction	CO2	361		361	0.11	0.59	0.06	0.72
5.C.2.5	other land converted to grassland, revegeta	CO2		-280	280	0.00	0.59	0.05	0.77
2.C.2	ferroalloys	CO2	204		204	0.06	0.65	0.03	0.80
4.A.3	enteric fermentation, sheep	CH4	159		159	0.05	0.70	0.03	0.83
2.C.3	aluminium	CO2	136		136	0.04	0.74	0.02	0.85
6.A	solid waste disposal on land	CH4	134		134	0.04	0.78	0.02	0.87
4.D.1	direct soil emissions	N2O	118		118	0.04	0.82	0.02	0.89
4.D.2	indirect soil emissions	N2O	95		95	0.03	0.84	0.02	0.91
1.AA.3a/d	transport	CO2	91		91	0.03	0.87	0.01	0.92
4.A.1	enteric fermentation, cattle	CH4	77		77	0.02	0.89	0.01	0.94
1.B.2	geothermal energy	CO2	67		67	0.02	0.91	0.01	0.95
2.A	Mineral production	CO2	52		52	0.02	0.93	0.01	0.96

Table A3. Key source analysis – trend assessment

			Base year estimate	Current year estimate	Asbolute estimate	Level assessment	Trend assessment	Contribution to trend	Cumulative total
			5535	6464	7832		0.35	1	
2.C.3	aluminium	CO2	136	1168	1168	0.15	0.11	0.32	0.32
5.C.2.3	wetlands converted to grassland	CO2	1478	1353	1353	0.17	0.04	0.12	0.43
1.AA.4c	fishing	CO2	655	517	517	0.07	0.03	0.08	0.51
1.AA.3b	road transport	CO2	521	851	851	0.11	0.03	0.08	0.59
5.C.2.5	other land converted to grassland, revegeta	CO2	-280	-548	548	0.07	0.02	0.07	0.66
5.b.	cropland	CO2	992	997	997	0.13	0.02	0.05	0.71
2.C.3	aluminium	PFC	420	349	349	0.04	0.02	0.04	0.75
5.A	forest land	CO2	-21	-135	135	0.02	0.01	0.03	0.78
1.B.2	geothermal energy	CO2	67	185	185	0.02	0.01	0.03	0.82
2.C.2	ferroalloys	CO2	204	339	339	0.04	0.01	0.03	0.85
1.AA.2	manufacturing industry and construction	CO2	361	343	343	0.04	0.01	0.02	0.87
2.F	consumption of halocarbons and SF6	HFC	0	66	66	0.01	0.01	0.02	0.89
4.A.3	enteric fermentation, sheep	CH4	159	129	129	0.02	0.01	0.02	0.91
6.A	solid waste disposal on land	CH4	134	212	212	0.03	0.01	0.02	0.93
1.AA.4a/b	residential/institutional/commercial	CO2	43	13	13	0.00	0.00	0.01	0.94
4.B	manure management	N2O	32	0	0	0.00	0.00	0.01	0.95

ANNEX II QUANTITATIVE uncertainty

TIER 1 UNCERTAINTY CALCULATION AND REPORTING OF SOURCES IN ICELAND

IPCC Source Category	Gas	Base year emissions (1990)	Year t emissions (2008)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combine uncertainty as % of total national emissions in year 2008	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF unc.	Uncertainty in trend in national emissions introduced by a.d.	Uncertainty introduced into the trend in total national emissions
	Gg CO_2 equivalents			%	%	%	%	%	%	%	%	%
1.A.3.b Transport - Road Transportation	CO_2	521.26	851.12	10.0	5.0	11.18	1.95	0.031	0.249	0.16	3.52	3.53
1.AA.2 Manufacturing industry and construction	CO_2	360.79	342.92	10.0	5.0	11.18	0.79	-0.051	0.100	-0.25	1.42	1.44
1.AA.4c Fishing	CO_2	655.49	517.33	5.0	5.0	7.07	0.75	-0.123	0.151	-0.61	1.07	1.23
1AA4.a/b residential/institutional/commercial	CO_2	43.15	27.51	5.0	5.0	7.07	0.04	-0.010	0.008	-0.05	0.06	0.08
1.B.2 Geothermal energy	CO_2	66.63	185.14	10.0	1.0	10.05	0.38	0.026	0.054	0.03	0.77	0.77
2.A.1 Cement Production	CO_2	51.56	60.83	5.0	6.5	8.20	0.10	-0.004	0.018	-0.02	0.13	0.13
2.C.2 Ferroalloys Production	CO_2	204.13	338.93	5.0	10.0	11.18	0.78	0.014	0.099	0.14	0.70	0.72
2.C.3 Aluminium Production	CO_2	136.49	1 167.92	5.0	10.0	11.18	2.68	0.285	0.342	2.85	2.42	3.74
4.A Enteric Fermentation	CH_4	264.98	230.63	20.0	50.0	53.85	2.54	-0.043	0.068	-2.17	1.91	2.89
6.A Solid Waste Disposal on Land	CH_4	152.56	211.79	15.0	50.0	52.20	2.27	-0.002	0.062	-0.09	1.32	1.32
1.A.3.b Transport - Road Transportation	N_2O	4.54	39.22	50.0	200.0	206.16	1.66	0.010	0.011	1.92	0.81	2.08
Direct emissions from agricultural soil	N_2O	118.08	133.15	20.0	100.0	101.98	2.78	-0.010	0.039	-1.04	1.10	1.52
Indirect emissions from Nitrogen used in agriculture	N_2O	94.92	107.92	20.0	100.0	101.98	2.26	-0.008	0.032	-0.81	0.89	1.21
2.C.3 Aluminium Production												
CF4	PFC	355.02	295.27	5.0	7.0	8.60	0.52	-0.062	0.086	-0.43	0.61	0.75
C2F6	PFC	64.61	53.73	5.0	22.0	22.56	0.25	-0.011	0.016	-0.25	0.11	0.27
Substitutes for Ozone Depleting Substances	HFC	0.00	65.85	20.0	50.0	53.85	0.73	0.019	0.019	0.96	0.55	1.11
Other non-key source emissions	All	320.73	250.85		30.0	30.00	1.54	-0.061	0.073	-1.82	0.00	1.82
	Total emissions (all sources):	**3 414.94**	**4 880.10**			**Total H :**	**6.6**	**Level Uncertainty**			**Total M :**	**7.4**

ANNEX III CRF SUMMARY 2 FOR 1990 TO 2008

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 228.34**	**446.91**	**675.16**	**IE,NA,NE,NO**	**419.63**	**1.05**	**5 771.09**
1. Energy	**1 751.76**	**4.67**	**26.86**				**1 783.29**
A. Fuel Combustion (Sectoral Approach)	1 685.13	4.67	26.86				1 716.66
1. Energy Industries	13.33	0.01	0.02				13.36
2. Manufacturing Industries and Construction	360.79	0.25	15.91				376.96
3. Transport	612.37	3.08	5.32				620.77
4. Other Sectors	698.64	1.33	5.61				705.57
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66.63	NA,NE,NO	NA,NO				66.63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66.63	NE,NO	NA,NO				66.63
2. Industrial Processes	**393.26**	**0.61**	**48.36**	**IE,NA,NE,NO**	**419.63**	**1.05**	**862.91**
A. Mineral Products	52.28	NE,NO	NE,NO				52.28
B. Chemical Industry	0.36	NE,NO	48.36	NA	NA	NA	48.72
C. Metal Production	340.62	0.61	NA	NA,NE,NO	419.63	NA,NO	760.86
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				IE,NA,NE,NO	NA,NE,NO	1.05	1.05
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**7.94**		**6.00**				**13.94**
4. Agriculture		**287.27**	**287.97**				**575.24**
A. Enteric Fermentation		264.98					264.98
B. Manure Management		22.28	31.74				54.02
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	256.23				256.23
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**2 056.19**	**1.81**	**298.15**				**2 356.15**
A. Forest Land	-19.39	NE,NO	0.16				-19.22
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	1 081.75	NE,NO	NE,NO				1 081.75
D. Wetlands	2.11	1.81	NA,NO				3.92
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.99				297.99
6. Waste	**19.19**	**152.56**	**7.82**				**179.57**
A. Solid Waste Disposal on Land	NA,NE,NO	133.86					133.86
B. Waste-water Handling		13.53	6.65				20.18
C. Waste Incineration	19.19	5.16	1.17				25.53
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	318.65	0.23	2.76				321.64
Aviation	219.65	0.03	1.92				221.61
Marine	99.00	0.20	0.84				100.03
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 414.94
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 771.09

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 148.41**	**445.62**	**667.01**	**IE,NA,NE,NO**	**348.34**	**3.20**	**5 612.57**
1. Energy	**1 707.17**	**4.80**	**26.31**				**1 738.28**
A. Fuel Combustion (Sectoral Approach)	1 640.53	4.80	26.31				1 671.65
1. Energy Industries	14.91	0.01	0.02				14.94
2. Manufacturing Industries and Construction	285.34	0.21	15.07				300.62
3. Transport	624.15	3.22	5.47				632.83
4. Other Sectors	716.14	1.36	5.75				723.25
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66.63	NA,NE,NO	NA,NO				66.63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66.63	NE,NO	NA,NO				66.63
2. Industrial Processes	**359.70**	**0.51**	**46.81**	**IE,NA,NE,NO**	**348.34**	**3.20**	**758.56**
A. Mineral Products	48.65	NE,NO	NE,NO				48.65
B. Chemical Industry	0.31	NE,NO	46.81	NA	NA	NA	47.12
C. Metal Production	310.74	0.51	NA	NA,NE,NO	348.34	NA,NO	659.59
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				IE,NA,NE,NO	NA,NE,NO	3.20	3.20
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**11.29**		**4.87**				**16.16**
4. Agriculture		**277.63**	**282.64**				**560.27**
A. Enteric Fermentation		255.61					255.61
B. Manure Management		22.02	30.72				52.73
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	251.92				251.92
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**2 051.21**	**6.53**	**298.47**				**2 356.20**
A. Forest Land	-20.67	NE,NO	0.22				-20.45
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	1 072.55	NE,NO	NE,NO				1 072.55
D. Wetlands	7.61	6.53	NA,NO				14.14
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	298.25				298.25
6. Waste	**19.04**	**156.16**	**7.91**				**183.11**
A. Solid Waste Disposal on Land	NA,NE,NO	137.83					137.83
B. Waste-water Handling		13.20	6.75				19.95
C. Waste Incineration	19.04	5.12	1.16				25.33
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	259.64	0.11	2.26				262.01
Aviation	221.99	0.03	1.94				223.96
Marine	37.65	0.08	0.32				38.05
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 256.37
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 612.57

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 259.14**	**445.42**	**648.46**	**0.07**	**155.28**	**1.33**	**5 509.69**
1. Energy	**1 832.74**	**5.03**	**26.03**				**1 863.80**
A. Fuel Combustion (Sectoral Approach)	1 766.11	5.03	26.03				1 797.17
1. Energy Industries	13.92	0.01	0.02				13.95
2. Manufacturing Industries and Construction	339.15	0.24	14.15				353.54
3. Transport	634.57	3.30	5.57				643.44
4. Other Sectors	778.46	1.49	6.29				786.24
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66.63	NA,NE,NO	NA,NO				66.63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66.63	NE,NO	NA,NO				66.63
2. Industrial Processes	**362.69**	**0.53**	**41.85**	**0.07**	**155.28**	**1.33**	**561.74**
A. Mineral Products	45.69	NE,NO	NE,NO				45.69
B. Chemical Industry	0.25	NE,NO	41.85	NA	NA	NA	42.10
C. Metal Production	316.74	0.53	NA	NA,NE,NO	155.28	NA,NO	472.55
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				0.07	NA,NE,NO	1.33	1.40
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**9.94**		**4.77**				**14.71**
4. Agriculture		**272.08**	**269.76**				**541.84**
A. Enteric Fermentation		250.17					250.17
B. Manure Management		21.90	29.78				51.68
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	239.98				239.98
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**2 035.25**	**6.53**	**298.09**				**2 339.87**
A. Forest Land	-24.25	NE,NO	0.30				-23.94
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	1 060.17	NE,NO	NE,NO				1 060.17
D. Wetlands	7.61	6.53	NA,NO				14.14
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.79				297.79
6. Waste	**18.53**	**161.25**	**7.95**				**187.73**
A. Solid Waste Disposal on Land	NA,NE,NO	141.79					141.79
B. Waste-water Handling		14.46	6.82				21.28
C. Waste Incineration	18.53	5.00	1.14				24.66
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	263.56	0.15	2.29				266.00
Aviation	203.62	0.03	1.78				205.43
Marine	59.95	0.12	0.51				60.57
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 169.82
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 509.69

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 351.96**	**449.80**	**660.70**	**0.27**	**74.86**	**1.34**	**5 538.94**
1. Energy	**1 893.05**	**5.11**	**27.57**				**1 925.73**
A. Fuel Combustion (Sectoral Approach)	1 826.42	5.11	27.57				1 859.10
1. Energy Industries	16.27	0.02	0.13				16.43
2. Manufacturing Industries and Construction	366.43	0.26	15.28				381.96
3. Transport	635.04	3.28	5.60				643.91
4. Other Sectors	808.68	1.56	6.56				816.79
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66.63	NA,NE,NO	NA,NO				66.63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66.63	NE,NO	NA,NO				66.63
2. Industrial Processes	**410.31**	**0.60**	**44.02**	**0.27**	**74.86**	**1.34**	**531.40**
A. Mineral Products	39.68	NE,NO	NE,NO				39.68
B. Chemical Industry	0.24	NE,NO	44.02	NA	NA	NA	44.26
C. Metal Production	370.39	0.60	NA	NA,NE,NO	74.86	NA,NO	445.85
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				0.27	NA,NE,NO	1.34	1.61
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8.50**		**4.71**				**13.21**
4. Agriculture		**272.69**	**279.38**				**552.07**
A. Enteric Fermentation		250.90					250.90
B. Manure Management		21.79	30.41				52.20
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	248.97				248.97
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**2 024.33**	**6.53**	**297.12**				**2 327.98**
A. Forest Land	-27.81	NE,NO	0.32				-27.50
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	1 052.82	NE,NO	NE,NO				1 052.82
D. Wetlands	7.61	6.53	NA,NO				14.14
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	296.81				296.81
6. Waste	**15.77**	**164.87**	**7.90**				**188.55**
A. Solid Waste Disposal on Land	NA,NE,NO	145.16					145.16
B. Waste-water Handling		15.24	6.89				22.12
C. Waste Incineration	15.77	4.48	1.02				21.27
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Memo Items: [(4)]							
International Bunkers	293.02	0.22	2.54				295.78
Aviation	195.64	0.03	1.71				197.38
Marine	97.38	0.19	0.82				98.40
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 210.96
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 538.94

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 301.99**	**454.44**	**667.57**	**0.67**	**44.57**	**1.34**	**5 470.59**
1. Energy	**1 855.45**	**5.10**	**27.74**				**1 888.28**
A. Fuel Combustion (Sectoral Approach)	1 788.82	5.10	27.74				1 821.65
1. Energy Industries	16.14	0.02	0.13				16.29
2. Manufacturing Industries and Construction	343.79	0.25	15.50				359.54
3. Transport	637.79	3.31	5.65				646.75
4. Other Sectors	791.10	1.52	6.45				799.07
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	66.63	NA,NE,NO	NA,NO				66.63
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	66.63	NE,NO	NA,NO				66.63
2. Industrial Processes	**411.28**	**0.57**	**44.33**	**0.67**	**44.57**	**1.34**	**502.76**
A. Mineral Products	37.37	NE,NO	NE,NO				37.37
B. Chemical Industry	0.35	NE,NO	44.33	NA	NA	NA	44.68
C. Metal Production	373.55	0.57	NA	NA,NE,NO	44.57	NA,NO	418.69
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				0.67	NA,NE,NO	1.34	2.01
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**10.02**		**3.88**				**13.89**
4. Agriculture		**273.67**	**286.78**				**560.46**
A. Enteric Fermentation		251.91					251.91
B. Manure Management		21.76	30.96				52.72
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	255.82				255.82
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**2 010.71**	**6.53**	**296.96**				**2 314.20**
A. Forest Land	-30.38	NE,NO	0.33				-30.06
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	1 041.76	NE,NO	NE,NO				1 041.76
D. Wetlands	7.61	6.53	NA,NO				14.14
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	296.63				296.63
6. Waste	**14.54**	**168.58**	**7.88**				**191.00**
A. Solid Waste Disposal on Land	NA,NE,NO	148.15					148.15
B. Waste-water Handling		16.24	6.93				23.18
C. Waste Incineration	14.54	4.18	0.95				19.67
D. Other	NA	NO	NO				NA,NO
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	307.10	0.22	2.66				309.98
Aviation	213.62	0.03	1.87				215.52
Marine	93.49	0.19	0.79				94.46
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 156.39
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 470.59

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 313.99**	**449.48**	**668.03**	**4.36**	**58.84**	**1.38**	**5 496.09**
1. Energy	**1 875.74**	**4.58**	**38.21**				**1 918.54**
A. Fuel Combustion (Sectoral Approach)	1 794.06	4.58	38.21				1 836.86
1. Energy Industries	18.95	0.03	0.17				19.15
2. Manufacturing Industries and Construction	359.56	0.27	19.29				379.13
3. Transport	613.50	2.73	12.20				628.43
4. Other Sectors	802.06	1.54	6.55				810.15
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	81.68	NA,NE,NO	NA,NO				81.68
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	81.68	NE,NO	NA,NO				81.68
2. Industrial Processes	**427.64**	**0.59**	**42.16**	**4.36**	**58.84**	**1.38**	**534.98**
A. Mineral Products	37.87	NE,NO	NE,NO				37.87
B. Chemical Industry	0.46	NE,NO	42.16	NA	NA	NA	42.62
C. Metal Production	389.32	0.59	NA	NA,NE,NO	58.84	NA,NO	448.75
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				4.36	NA,NE,NO	1.38	5.74
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**9.38**		**4.71**				**14.09**
4. Agriculture		**264.67**	**277.39**				**542.06**
A. Enteric Fermentation		242.95					242.95
B. Manure Management		21.72	29.21				50.93
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	248.18				248.18
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 988.41**	**6.53**	**297.56**				**2 292.49**
A. Forest Land	-37.75	NE,NO	0.38				-37.37
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	1 026.82	NE,NO	NE,NO				1 026.82
D. Wetlands	7.61	6.53	NA,NO				14.14
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.18				297.18
6. Waste	**12.82**	**173.11**	**8.00**				**193.93**
A. Solid Waste Disposal on Land	NA,NE,NO	151.43					151.43
B. Waste-water Handling		17.74	6.96				24.71
C. Waste Incineration	12.82	3.77	0.86				17.44
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Memo Items: [(4)]							
International Bunkers	380.15	0.32	3.28				383.76
Aviation	236.15	0.04	2.07				238.25
Marine	144.00	0.29	1.21				145.50
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 203.60
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 496.09

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4 389.27**	**457.32**	**689.00**	**8.03**	**25.15**	**1.38**	**5 570.16**
1. Energy	**1 966.68**	**4.75**	**38.16**				**2 009.59**
A. Fuel Combustion (Sectoral Approach)	1 884.50	4.75	38.16				1 927.41
1. Energy Industries	15.34	0.04	0.20				15.58
2. Manufacturing Industries and Construction	399.02	0.30	18.78				418.10
3. Transport	604.42	2.76	12.11				619.29
4. Other Sectors	865.72	1.66	7.06				874.44
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	82.18	NA,NE,NO	NA,NO				82.18
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	82.18	NE,NO	NA,NO				82.18
2. Industrial Processes	**427.18**	**0.57**	**49.29**	**8.03**	**25.15**	**1.38**	**511.61**
A. Mineral Products	41.78	NE,NO	NE,NO				41.78
B. Chemical Industry	0.40	NE,NO	49.29	NA	NA	NA	49.69
C. Metal Production	385.00	0.57	NA	NA,NE,NO	25.15	NA,NO	410.72
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				8.03	NA,NE,NO	1.38	9.41
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**9.00**		**4.71**				**13.71**
4. Agriculture		**266.57**	**291.51**				**558.08**
A. Enteric Fermentation		244.56					244.56
B. Manure Management		22.01	30.36				52.36
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	261.15				261.15
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**1 974.93**	**7.90**	**297.34**				**2 280.18**
A. Forest Land	-40.56	NE,NO	0.38				-40.19
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	1 014.55	NE,NO	NE,NO				1 014.55
D. Wetlands	9.22	7.90	NA,NO				17.13
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	296.97				296.97
6. Waste	**11.49**	**177.53**	**7.98**				**196.99**
A. Solid Waste Disposal on Land	NA,NE,NO	155.25					155.25
B. Waste-water Handling		18.66	7.01				25.67
C. Waste Incineration	11.49	3.44	0.78				15.72
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	395.45	0.29	3.42				399.17
Aviation	271.51	0.04	2.38				273.93
Marine	123.95	0.25	1.04				125.24
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 289.98
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 570.16

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 461.51**	**453.46**	**686.30**	**12.52**	**82.36**	**1.39**	**5 697.54**
1. Energy	**2 002.43**	**4.27**	**49.07**				**2 055.76**
A. Fuel Combustion (Sectoral Approach)	1 931.05	4.27	49.07				1 984.38
1. Energy Industries	10.25	0.03	0.20				10.48
2. Manufacturing Industries and Construction	467.41	0.35	22.64				490.40
3. Transport	615.75	2.26	19.35				637.36
4. Other Sectors	837.63	1.62	6.88				846.14
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	71.38	NA,NE,NO	NA,NO				71.38
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	71.38	NE,NO	NA,NO				71.38
2. Industrial Processes	**485.06**	**0.60**	**41.11**	**12.52**	**82.36**	**1.39**	**623.03**
A. Mineral Products	46.55	NE,NO	NE,NO				46.55
B. Chemical Industry	0.44	NE,NO	41.11	NA	NA	NA	41.54
C. Metal Production	438.08	0.60	NA	NA,NE,NO	82.36	NA,NO	521.04
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				12.52	NA,NE,NO	1.39	13.91
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8.06**		**4.71**				**12.77**
4. Agriculture		**261.64**	**285.60**				**547.24**
A. Enteric Fermentation		240.22					240.22
B. Manure Management		21.43	30.29				51.72
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	255.30				255.30
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 954.89**	**7.90**	**297.80**				**2 260.60**
A. Forest Land	-45.91	NE,NO	0.41				-45.50
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	999.86	NE,NO	NE,NO				999.86
D. Wetlands	9.22	7.90	NA,NO				17.13
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.39				297.39
6. Waste	**11.07**	**179.05**	**8.02**				**198.14**
A. Solid Waste Disposal on Land	NA,NE,NO	156.86					156.86
B. Waste-water Handling		18.67	7.07				25.75
C. Waste Incineration	11.07	3.34	0.76				15.18
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	440.80	0.34	3.81				444.95
Aviation	292.12	0.04	2.56				294.72
Marine	148.68	0.30	1.25				150.23
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 436.94
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 697.54

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 448.41**	**456.35**	**684.87**	**20.35**	**180.13**	**1.76**	**5 791.87**
1. Energy	**1 988.68**	**4.24**	**49.58**				**2 042.50**
A. Fuel Combustion (Sectoral Approach)	1 894.60	4.24	49.58				1 948.42
1. Energy Industries	13.56	0.03	0.20				13.79
2. Manufacturing Industries and Construction	445.87	0.33	22.89				469.09
3. Transport	619.00	2.30	19.83				641.13
4. Other Sectors	816.18	1.57	6.66				824.41
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	94.08	NA,NE,NO	NA,NO				94.08
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	94.08	NE,NO	NA,NO				94.08
2. Industrial Processes	**512.73**	**0.44**	**35.84**	**20.35**	**180.13**	**1.76**	**751.25**
A. Mineral Products	54.39	NE,NO	NE,NO				54.39
B. Chemical Industry	0.40	NE,NO	35.84	NA	NA	NA	36.23
C. Metal Production	457.95	0.44	NA	NA,NE,NO	180.13	NA,NO	638.53
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				20.35	NA,NE,NO	1.76	22.11
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8.09**		**4.96**				**13.05**
4. Agriculture		**264.89**	**288.22**				**553.11**
A. Enteric Fermentation		243.17					243.17
B. Manure Management		21.72	30.59				52.30
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	257.64				257.64
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 929.52**	**7.97**	**298.23**				**2 235.72**
A. Forest Land	-51.74	NE,NO	0.50				-51.24
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	980.25	NE,NO	NE,NO				980.25
D. Wetlands	9.30	7.97	NA,NO				17.27
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.72				297.72
6. Waste	**9.38**	**178.81**	**8.04**				**196.23**
A. Solid Waste Disposal on Land	NA,NE,NO	158.27					158.27
B. Waste-water Handling		17.30	7.15				24.45
C. Waste Incineration	9.38	3.07	0.70				13.16
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	514.67	0.40	4.44				519.51
Aviation	338.13	0.05	2.96				341.14
Marine	176.54	0.35	1.48				178.37
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 556.15
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 791.87

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 628.12**	**459.44**	**707.44**	**26.37**	**173.21**	**10.94**	**6 005.52**
1. Energy	**2 046.82**	**3.60**	**61.29**				**2 111.70**
A. Fuel Combustion (Sectoral Approach)	1 923.86	3.60	61.29				1 988.74
1. Energy Industries	10.69	0.03	0.20				10.92
2. Manufacturing Industries and Construction	470.83	0.36	25.04				496.23
3. Transport	640.69	1.67	29.49				671.84
4. Other Sectors	801.65	1.54	6.56				809.75
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	122.96	NA,NE,NO	NA,NO				122.96
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	122.96	NE,NO	NA,NO				122.96
2. Industrial Processes	**659.15**	**0.68**	**36.18**	**26.37**	**173.21**	**10.94**	**906.52**
A. Mineral Products	61.46	NE,NO	NE,NO				61.46
B. Chemical Industry	0.43	NE,NO	36.18	NA	NA	NA	36.61
C. Metal Production	597.26	0.68	NA	NA,NE,NO	173.21	NA,NO	771.15
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				26.37	NA,NE,NO	10.94	37.31
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8.99**		**4.68**				**13.67**
4. Agriculture		**265.51**	**299.34**				**564.84**
A. Enteric Fermentation		243.94					243.94
B. Manure Management		21.56	30.62				52.19
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	268.71				268.71
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 905.48**	**7.97**	**297.92**				**2 211.37**
A. Forest Land	-55.91	NE,NO	0.53				-55.38
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	960.38	NE,NO	NE,NO				960.38
D. Wetlands	9.30	7.97	NA,NO				17.27
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.38				297.38
6. Waste	**7.67**	**181.69**	**8.04**				**197.40**
A. Solid Waste Disposal on Land	NA,NE,NO	160.77					160.77
B. Waste-water Handling		18.08	7.25				25.34
C. Waste Incineration	7.67	2.66	0.60				10.94
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	527.25	0.38	4.57				532.20
Aviation	363.37	0.05	3.18				366.61
Marine	163.88	0.33	1.38				165.59
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 794.15
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	6 005.52

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4 653.93**	**453.77**	**685.81**	**27.44**	**127.16**	**2.97**	**5 951.09**
1. Energy	**1 988.43**	**3.47**	**61.13**				**2 053.03**
A. Fuel Combustion (Sectoral Approach)	1 824.95	3.47	61.13				1 889.55
1. Energy Industries	9.52	0.03	0.20				9.75
2. Manufacturing Industries and Construction	423.87	0.33	25.50				449.70
3. Transport	642.83	1.65	29.29				673.77
4. Other Sectors	748.73	1.45	6.15				756.33
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	163.48	NA,NE,NO	NA,NO				163.48
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	163.48	NE,NO	NA,NO				163.48
2. Industrial Processes	**768.81**	**0.94**	**18.63**	**27.44**	**127.16**	**2.97**	**945.95**
A. Mineral Products	65.68	NE,NO	NE,NO				65.68
B. Chemical Industry	0.41	NE,NO	18.63	NA	NA	NA	19.04
C. Metal Production	702.72	0.94	NA	NA,NE,NO	127.16	NA,NO	830.82
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				27.44	NA,NE,NO	2.97	30.41
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**10.36**		**4.53**				**14.89**
4. Agriculture		**256.11**	**295.88**				**551.99**
A. Enteric Fermentation		234.99					234.99
B. Manure Management		21.12	28.95				50.07
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	266.93				266.93
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**1 879.12**	**7.97**	**297.53**				**2 184.62**
A. Forest Land	-64.92	NE,NO	0.69				-64.23
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	943.01	NE,NO	NE,NO				943.01
D. Wetlands	9.30	7.97	NA,NO				17.27
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	296.84				296.84
6. Waste	**7.21**	**185.28**	**8.12**				**200.61**
A. Solid Waste Disposal on Land	NA,NE,NO	163.97					163.97
B. Waste-water Handling		18.59	7.35				25.95
C. Waste Incineration	7.21	2.55	0.58				10.34
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	626.29	0.50	5.41				632.20
Aviation	407.74	0.06	3.57				411.37
Marine	218.55	0.44	1.84				220.82
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 766.47
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 951.09

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 642.43**	**459.25**	**678.12**	**30.82**	**91.66**	**4.52**	**5 906.79**
1. Energy	**1 952.53**	**3.35**	**60.31**				**2 016.19**
A. Fuel Combustion (Sectoral Approach)	1 798.05	3.35	60.31				1 861.71
1. Energy Industries	9.27	0.03	0.20				9.50
2. Manufacturing Industries and Construction	470.93	0.35	25.08				496.36
3. Transport	653.53	1.68	29.58				684.79
4. Other Sectors	664.32	1.28	5.45				671.06
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	154.48	NA,NE,NO	NA,NO				154.48
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	154.48	NE,NO	NA,NO				154.48
2. Industrial Processes	**805.29**	**0.91**	**16.15**	**30.82**	**91.66**	**4.52**	**949.35**
A. Mineral Products	58.99	NE,NO	NE,NO				58.99
B. Chemical Industry	0.49	NE,NO	16.15	NA	NA	NA	16.64
C. Metal Production	745.80	0.91	NA	NA,NE,NO	91.66	NA,NO	838.37
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				30.82	NA,NE,NO	4.52	35.34
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**12.66**		**4.03**				**16.69**
4. Agriculture		**255.80**	**291.83**				**547.64**
A. Enteric Fermentation		234.72					234.72
B. Manure Management		21.08	28.66				49.75
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	263.17				263.17
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 865.27**	**7.97**	**297.62**				**2 170.85**
A. Forest Land	-68.98	NE,NO	0.72				-68.27
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	933.23	NE,NO	NE,NO				933.23
D. Wetlands	9.30	7.97	NA,NO				17.27
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	296.90				296.90
6. Waste	**6.69**	**191.21**	**8.18**				**206.08**
A. Solid Waste Disposal on Land	NA,NE,NO	170.28					170.28
B. Waste-water Handling		18.34	7.44				25.78
C. Waste Incineration	6.69	2.43	0.55				9.67
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	498.17	0.35	4.32				502.83
Aviation	349.13	0.05	3.06				352.24
Marine	149.04	0.30	1.26				150.60
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 735.94
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 906.79

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4 713.39**	**446.53**	**644.61**	**31.89**	**72.54**	**3.37**	**5 912.32**
1. Energy	**2 030.08**	**3.50**	**59.63**				**2 093.21**
A. Fuel Combustion (Sectoral Approach)	1 870.74	3.50	59.63				1 933.86
1. Energy Industries	10.96	0.04	0.20				11.20
2. Manufacturing Industries and Construction	474.54	0.35	23.52				498.42
3. Transport	657.22	1.69	29.89				688.80
4. Other Sectors	728.01	1.42	6.01				735.44
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	159.35	NA,NE,NO	NA,NO				159.35
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	159.35	NE,NO	NA,NO				159.35
2. Industrial Processes	**822.84**	**0.97**	**NA,NE,NO**	**31.89**	**72.54**	**3.37**	**931.60**
A. Mineral Products	39.76	NE,NO	NE,NO				39.76
B. Chemical Industry	0.45	NE,NO	NE,NO	NA	NA	NA	0.45
C. Metal Production	782.62	0.97	NA	NA,NE,NO	72.54	NA,NO	856.13
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				31.89	NA,NE,NO	3.37	35.26
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8.92**		**4.03**				**12.95**
4. Agriculture		**250.83**	**274.96**				**525.78**
A. Enteric Fermentation		230.60					230.60
B. Manure Management		20.22	27.92				48.15
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	247.04				247.04
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**1 845.33**	**7.97**	**297.80**				**2 151.10**
A. Forest Land	-75.53	NE,NO	0.76				-74.77
B. Cropland	991.72	NE,NO	NE,NO				991.72
C. Grassland	919.85	NE,NO	NE,NO				919.85
D. Wetlands	9.30	7.97	NA,NO				17.27
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.03				297.03
6. Waste	**6.21**	**183.27**	**8.20**				**197.68**
A. Solid Waste Disposal on Land	NA,NE,NO	161.20					161.20
B. Waste-water Handling		19.59	7.49				27.08
C. Waste Incineration	6.21	2.31	0.53				9.05
D. Other	NA	0.17	0.19				0.35
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	517.17	0.46	4.46				522.10
Aviation	309.85	0.05	2.71				312.61
Marine	207.32	0.41	1.75				209.49
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 761.22
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 912.32

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4 672.90**	**449.66**	**633.73**	**37.80**	**59.78**	**3.51**	**5 857.38**
1. Energy	**2 013.80**	**3.52**	**58.87**				**2 076.19**
A. Fuel Combustion (Sectoral Approach)	1 875.91	3.52	58.87				1 938.30
1. Energy Industries	10.23	0.03	0.20				10.46
2. Manufacturing Industries and Construction	427.33	0.33	21.52				449.18
3. Transport	751.18	1.81	31.44				784.43
4. Other Sectors	687.17	1.35	5.71				694.23
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	137.89	NA,NE,NO	NA,NO				137.89
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	137.89	NE,NO	NA,NO				137.89
2. Industrial Processes	**826.79**	**0.94**	**NA,NE,NO**	**37.80**	**59.78**	**3.51**	**928.82**
A. Mineral Products	33.48	NE,NO	NE,NO				33.48
B. Chemical Industry	0.48	NE,NO	NE,NO	NA	NA	NA	0.48
C. Metal Production	792.83	0.94	NA	NA,NE,NO	59.78	NA,NO	853.56
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				37.80	NA,NE,NO	3.51	41.31
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**6.33**		**3.72**				**10.05**
4. Agriculture		**248.24**	**263.63**				**511.88**
A. Enteric Fermentation		228.41					228.41
B. Manure Management		19.84	27.44				47.28
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	236.19				236.19
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**1 820.69**	**7.97**	**299.17**				**2 127.83**
A. Forest Land	-83.79	NE,NO	0.78				-83.01
B. Cropland	994.08	NE,NO	NE,NO				994.08
C. Grassland	901.10	NE,NO	NE,NO				901.10
D. Wetlands	9.30	7.97	NA,NO				17.27
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	298.39				298.39
6. Waste	**5.30**	**188.98**	**8.34**				**202.61**
A. Solid Waste Disposal on Land	NA,NE,NO	165.37					165.37
B. Waste-water Handling		21.13	7.55				28.68
C. Waste Incineration	5.30	2.23	0.51				8.03
D. Other	NA	0.25	0.28				0.53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	476.72	0.34	4.13				481.19
Aviation	333.00	0.05	2.92				335.97
Marine	143.72	0.29	1.21				145.22
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 729.55
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 857.38

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**4 716.60**	**441.19**	**632.26**	**42.30**	**38.58**	**3.39**	**5 874.31**
1. Energy	**2 069.04**	**3.64**	**64.52**				**2 137.20**
A. Fuel Combustion (Sectoral Approach)	1 944.96	3.64	64.52				2 013.12
1. Energy Industries	9.93	0.04	0.20				10.17
2. Manufacturing Industries and Construction	462.10	0.36	25.79				488.26
3. Transport	803.26	1.91	32.77				837.93
4. Other Sectors	669.66	1.34	5.76				676.77
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	124.08	NA,NE,NO	NA,NO				124.08
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	124.08	NE,NO	NA,NO				124.08
2. Industrial Processes	**848.59**	**0.96**	**NA,NE,NO**	**42.30**	**38.58**	**3.39**	**933.81**
A. Mineral Products	51.45	NE,NO	NE,NO				51.45
B. Chemical Industry	0.39	NE,NO	NE,NO	NA	NA	NA	0.39
C. Metal Production	796.75	0.96	NA	NA,NE,NO	38.58	NA,NO	836.29
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 (2)				42.30	NA,NE,NO	3.39	45.69
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**6.91**		**3.41**				**10.32**
4. Agriculture		**242.81**	**256.44**				**499.25**
A. Enteric Fermentation		223.46					223.46
B. Manure Management		19.35	27.14				46.49
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE	229.30				229.30
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry(1)	**1 789.57**	**7.97**	**299.63**				**2 097.17**
A. Forest Land	-89.12	NE,NO	0.83				-88.29
B. Cropland	994.24	NE,NO	NE,NO				994.24
C. Grassland	875.08	NE,NO	NE,NO				875.08
D. Wetlands	9.30	7.97	NA,NO				17.27
E. Settlements	0.07	NE	NE				0.07
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	298.80				298.80
6. Waste	**2.49**	**185.81**	**8.26**				**196.56**
A. Solid Waste Disposal on Land	NA,NE,NO	164.83					164.83
B. Waste-water Handling		19.17	7.62				26.80
C. Waste Incineration	2.49	1.55	0.35				4.40
D. Other	NA	0.25	0.28				0.53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	576.21	0.45	4.98				581.64
Aviation	380.00	0.06	3.33				383.39
Marine	196.21	0.39	1.65				198.25
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 777.14
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 874.31

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**4 635.30**	**440.18**	**639.45**	**48.54**	**26.09**	**3.39**	**5 792.95**
1. Energy	**2 026.24**	**3.27**	**72.14**				**2 101.65**
A. Fuel Combustion (Sectoral Approach)	1 902.86	3.27	72.14				1 978.26
1. Energy Industries	12.68	0.04	0.20				12.91
2. Manufacturing Industries and Construction	425.40	0.35	27.85				453.60
3. Transport	808.94	1.57	38.43				848.93
4. Other Sectors	655.85	1.31	5.66				662.82
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	123.38	NA,NE,NO	NA,NO				123.38
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	123.38	NE,NO	NA,NO				123.38
2. Industrial Processes	**837.77**	**0.97**	**NA,NE,NO**	**48.54**	**26.09**	**3.39**	**916.76**
A. Mineral Products	55.72	NE,NO	NE,NO				55.72
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	782.04	0.97	NA	NA,NE,NO	26.09	NA,NO	809.10
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				48.54	NA,NE,NO	3.39	51.93
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**12.89**		**3.29**				**16.18**
4. Agriculture		**242.88**	**255.51**				**498.39**
A. Enteric Fermentation		223.17					223.17
B. Manure Management		19.72	27.18				46.90
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	228.33				228.33
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 758.38**	**7.97**	**300.05**				**2 066.39**
A. Forest Land	-100.60	NE,NO	0.83				-99.78
B. Cropland	995.17	NE,NO	NE,NO				995.17
C. Grassland	854.44	NE,NO	NE,NO				854.44
D. Wetlands	9.30	7.97	NA,NE,NO				17.27
E. Settlements	0.07	NE	NE				0.07
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	299.22				299.22
6. Waste	**0.03**	**185.09**	**8.47**				**193.58**
A. Solid Waste Disposal on Land	NA,NE,NO	166.74					166.74
B. Waste-water Handling		16.97	7.78				24.75
C. Waste Incineration	0.03	0.96	0.22				1.21
D. Other	NA	0.42	0.47				0.89
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	532.59	0.28	4.62				537.50
Aviation	421.63	0.06	3.69				425.39
Marine	110.96	0.22	0.93				112.11
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	3 726.56
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5 792.95

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**4 778.09**	**463.53**	**667.54**	**51.57**	**333.22**	**6.98**	**6 300.95**
1. Energy	**2 103.50**	**3.29**	**71.72**				**2 178.51**
A. Fuel Combustion (Sectoral Approach)	1 947.01	3.29	71.72				2 022.03
1. Energy Industries	15.07	0.06	0.34				15.47
2. Manufacturing Industries and Construction	406.89	0.32	25.31				432.52
3. Transport	951.27	1.76	41.07				994.09
4. Other Sectors	573.79	1.16	5.00				579.95
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	156.48	NA,NE,NO	NA,NO				156.48
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	156.48	NE,NO	NA,NO				156.48
2. Industrial Processes	**940.82**	**0.99**	**NA,NE,NO**	**51.57**	**333.22**	**6.98**	**1 333.60**
A. Mineral Products	62.72	NE,NO	NE,NO				62.72
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	878.11	0.99	NA	NA,NE,NO	333.22	NA,NO	1 212.32
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [2]				51.57	NA,NE,NO	6.98	58.56
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**5.93**		**3.43**				**9.36**
4. Agriculture		**245.57**	**282.87**				**528.44**
A. Enteric Fermentation		225.17					225.17
B. Manure Management		20.40	27.77				48.18
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [3]		NA,NE	255.10				255.10
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry [1]	**1 727.82**	**9.27**	**300.60**				**2 037.69**
A. Forest Land	-112.55	NE,NO	0.86				-111.69
B. Cropland	995.26	NE,NO	NE,NO				995.26
C. Grassland	834.85	0.07	0.03				834.94
D. Wetlands	9.30	9.20	0.45				18.96
E. Settlements	0.96	NE	NE				0.96
F. Other Land	NE	NE	NE				NE
G. Other	IE,NE,NO	NA,NE,NO	299.26				299.26
6. Waste	**0.03**	**204.41**	**8.92**				**213.35**
A. Solid Waste Disposal on Land	NA,NE,NO	186.06					186.06
B. Waste-water Handling		16.85	7.99				24.84
C. Waste Incineration	0.03	0.83	0.19				1.04
D. Other	NA	0.67	0.74				1.42
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [4]							
International Bunkers	637.13	0.35	5.53				643.00
Aviation	499.89	0.07	4.38				504.35
Marine	137.23	0.27	1.15				138.66
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4 263.26
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	6 300.95

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS

(Sheet 1 of 1)

Inventory 2007

Submission 2010 v1.1

ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**5 009.99**	**484.05**	**686.39**	**57.80**	**281.13**	**9.86**	**6 529.22**
1. Energy	**2 158.50**	**3.36**	**72.52**				**2 234.37**
A. Fuel Combustion (Sectoral Approach)	2 006.98	3.36	72.52				2 082.85
1. Energy Industries	29.09	0.07	0.40				29.56
2. Manufacturing Industries and Construction	400.21	0.32	25.42				425.94
3. Transport	986.01	1.78	41.53				1 029.32
4. Other Sectors	591.67	1.19	5.17				598.03
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	151.52	NA,NE,NO	NA,NO				151.52
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	151.52	NE,NO	NA,NO				151.52
2. Industrial Processes	**1 134.32**	**1.04**	**NA,NE,NO**	**57.80**	**281.13**	**9.86**	**1 484.14**
A. Mineral Products	64.52	NE,NO	NE,NO				64.52
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1 069.79	1.04	NA	NA,NE,NO	281.13	NA,NO	1 351.96
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				57.80	NA,NE,NO	9.86	67.66
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**8.08**		**4.16**				**12.24**
4. Agriculture		**248.68**	**302.12**				**550.80**
A. Enteric Fermentation		227.89					227.89
B. Manure Management		20.79	28.03				48.82
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	274.09				274.09
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 709.07**	**13.92**	**298.34**				**2 021.33**
A. Forest Land	-123.35	NE,NO	0.88				-122.47
B. Cropland	996.52	NE,NO	NE,NO				996.52
C. Grassland	819.65	NE,NO	NE,NO				819.65
D. Wetlands	16.18	13.92	NA,NE,NO				30.11
E. Settlements	0.07	NE	NE				0.07
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	297.46				297.46
6. Waste	**0.03**	**217.05**	**9.25**				**226.33**
A. Solid Waste Disposal on Land	NA,NE,NO	200.47					200.47
B. Waste-water Handling		14.91	8.13				23.05
C. Waste Incineration	0.03	0.83	0.19				1.04
D. Other	NA	0.84	0.93				1.77
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	718.45	0.49	6.21				725.15
Aviation	511.53	0.08	4.48				516.09
Marine	206.92	0.41	1.73				209.06
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4 507.89
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	6 529.22

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2010 v1.1
ICELAND

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**5 277.66**	**481.32**	**695.91**	**66.77**	**349.00**	**5.94**	**6 876.60**
1. Energy	**2 019.28**	**3.13**	**69.20**				**2 091.61**
A. Fuel Combustion (Sectoral Approach)	1 834.14	3.13	69.20				1 906.47
1. Energy Industries	14.25	0.06	0.33				14.64
2. Manufacturing Industries and Construction	342.92	0.28	24.22				367.42
3. Transport	932.13	1.70	39.91				973.73
4. Other Sectors	544.85	1.09	4.74				550.68
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	185.14	NA,NE,NO	NA,NO				185.14
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	185.14	NE,NO	NA,NO				185.14
2. Industrial Processes	**1 569.55**	**0.88**	**NA,NE,NO**	**66.77**	**349.00**	**5.94**	**1 992.15**
A. Mineral Products	62.70	NE,NO	NE,NO				62.70
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1 506.86	0.88	NA	NA,NE,NO	349.00	NA,NO	1 856.74
D. Other Production	NE						NE
E. Production of Halocarbons and SF_6				NA,NO	NA,NO	NA,NO	NA,NO
F. Consumption of Halocarbons and SF_6 [(2)]				66.77	NA,NE,NO	5.94	72.72
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**5.82**		**3.10**				**8.92**
4. Agriculture		**251.59**	**314.79**				**566.39**
A. Enteric Fermentation		230.63					230.63
B. Manure Management		20.97	27.77				48.73
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE	287.03				287.03
E. Prescribed Burning of Savannas		NA	NA				NA
F. Field Burning of Agricultural Residues		NA,NO	NA,NO				NA,NO
G. Other		NA	NA				NA
5. Land Use, Land-Use Change and Forestry[(1)]	**1 682.99**	**13.92**	**299.59**				**1 996.50**
A. Forest Land	-135.21	NE,NO	0.85				-134.36
B. Cropland	997.24	NE,NO	NE,NO				997.24
C. Grassland	804.78	NE,NO	NE,NO				804.78
D. Wetlands	16.18	13.92	NA,NE,NO				30.11
E. Settlements	NA,NE,NO	NE	NE				NA,NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	298.74				298.74
6. Waste	**NA,NE,NO**	**211.79**	**9.24**				**221.03**
A. Solid Waste Disposal on Land	NA,NE,NO	195.70					195.70
B. Waste-water Handling		14.50	8.14				22.63
C. Waste Incineration	NA	0.75	0.17				0.92
D. Other	NA	0.84	0.93				1.77
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	656.36	0.51	5.64				662.52
Aviation	427.83	0.06	3.75				431.64
Marine	228.53	0.45	1.90				230.88
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**NA,NO**						**NA,NO**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	4 880.10
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	6 876.60

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

ANNEX IV FACT SHEET FOR SINGLE PROJECTS

Fact sheet Single Projects under 14/CP.7

Name of the single project	Rio Tinto Alcan – expansion of aluminium plant
Name of the company/ production facility	Rio Tinto Alcan
Location of the project	PO 224, 220 Hafnarfjordur, Iceland
NIR category	2.C.3 Aluminium production
Description of the industrial process facility	Aluminium production started at the Aluminium plant in Straumsvík in 1969. The plant consisted in the beginning of one potline. In 1972 a second potline was taken into operation. In 1996 a further expansion of the plant took place. The project involves an expansion in the plant capacity by building a new potline with increased current in the electrolytic pots. At the same time current was also increased in potlines one and two. This has led to increased production in potlines one and two. The process used in all potlines is PFPB with automatic multiple point feed.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Aluminium production plant in Straumsvik and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2172 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	- Iceland's total CO_2 emissions for 1990 were 2172 Gg - total industrial CO_2 emissions from the project in 2008 were 131 Gg or 6,0% of the 1990 CO_2 emissions. - this is higher than the 5% threshold in paragraph 2.
Reporting of CO2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2008 to 87,199 tonnes of aluminium (187,397 tonnes in 2007 compared to 100,198 tonnes in 1995). The resulting CO_2 emissions are 131 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in for the expanded part in 2008 is thus 1.47 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and paragraph 5.	Rio Tinto Alcan uses LPG for heating of melting pots and residual fuel oil in the foundry. In 2008 the total energy consumption was 3,468 tonnes of residual fuel oil, 389 tonnes of gas oil and 151 tonnes of LPG leading to emissions of 12.4 Gg of GHG. The EF for residual fuel oil is 3.08 t CO_2 eq per tonne of fuel. The EF for gas oil is 3.18 t CO_2 eq per tonne of fuel. The EF for LPG is 2.95 t CO_2 eq per tonne of fuel. The IEF for energy use is 0.07 t CO_2 eq per tonne of aluminium. These emissions are reported in the Energy sector. In 2008 the total use of electricity was 2,922 GWh, thereof 1360 GWh were used for the expansion project. - as stated in chapter 3.2. almost all energy in Iceland is produced from renewable energy sources (99,97%). Electricity for all heavy industry in Iceland

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

	is produced from renewable energy sources. The average emissions per kWh from electricity production in Iceland is 13.2 g. The total CO_2 emissions from the electricity use for the project amounts to 18 Gg. - Had the energy been from coal powered power plant the per kWh emissions would amount to 954 Gg. The resulting emissions from electricity use in the project would thus have amounted to 1297 Gg. The resulting emissions savings are 1279 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	To minimize process emissions BAT, as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is used in the production: - all pots are closed and the pot gases are collected and cleaned via a dry absorption unit; the technique is defined as BAT. - prebake anodes are used and automatic multiple point feed. - Besides that computer control is used in the potlines to minimize energy use and formation of PFC. BEP is used in the process and the facility has a certified environmental management system according to ISO 14001 . The environmental management system was certified in 1997. Besides the environmental management system , the facility also has a certified ISO 9001 quality management system and an OHSAS 18001 occupational health and safety management system .

*http://unfccc.int/resource/docs/2007/sbi/eng/30.pdf

Fact sheet Single Projects under 14/CP.7

Name of the single project	Elkem Iceland – expansion of ferrosilicon plant
Name of the company/ production facility	Elkem Iceland
Location of the project	Grundartanga, 301 Akranes, Iceland
NIR category	2.C.2 Ferrosilicon production
Description of the industrial process facility	The Elkem Iceland Ferrosilicon plant at Grundartangi was established in 1977, when construction of two furnaces started. The first furnace came on stream in 1979 and the second furnace a year later. The production capacity of the two furnaces was in the beginning 60,000 tonnes of ferrosilicon, but was later increased to 72,000 tonnes. In 1993 a project started enabling over lasting of the furnaces in comparison to design. Thus it has been possible since to increase the production in those furnaces. In 1999 a third furnace was taken into operation. The project involves an expansion in the plant capacity by building a new furnace as well as over lasting the older furnaces. Electric (submerged) arc furnaces with Soederberg electrodes are used. All furnaces are semi-covered. Furnace 3 can not use wood in the process.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Ferrosilicon plant in Grundartangi and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2172 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	- Iceland's total CO_2 emissions for 1990 were 2172 Gg. - total industrial CO_2 emissions from the project in 2008 were 140 Gg or 6,4% of the 1990 CO_2 emissions. - this is higher than the 5% threshold in paragraph 2.
Reporting of CO2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2008 to 39,642 tonnes of ferrosilicon (all production in furnace 3). The resulting CO_2 emissions are 140 Gg. CO_2 emissions are calculated based on the quantity of coal and coke as reducing agents, as well as from the consumption of electrodes, using emission factors from the IPCC Guidelines. The implied emission factor in 2008 was 3.52 t CO_2 per tonne of ferrosilicon. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and paragraph 5.	Elkem Iceland uses gasoil for heating of melting pots In 2008 the total energy consumption was 0.25 tonnes of gasoil leading to emissions of 0.8 Gg of GHG. The EF for gasoil is 3.18 t CO_2 eq per tonne of fuel These emissions are reported in the Energy sector. In 2008 the total use of electricity was 815 GWh, thereof 335 GWh were used for the expansion project. - as stated in chapter 3.2. almost all energy in Iceland is produced from renewable energy sources (99,97%). Electricity for all heavy industry in Iceland is produced from renewable energy sources. The average emissions per kWh from electricity production in Iceland is 13.2 g. The total CO_2 emissions from the electricity use for the project amounts to 4 Gg. - Had the energy been from coal powered power plant the per kWh emissions would amount to 954 g. The resulting emissions from the project would thus

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

	have amounted to 320 Gg. The resulting emissions savings are 315 Gg.
Provide evidence that the project fulfils paragraph 2.(c)	To minimize process emissions BAT, as defined in the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is used in the production. Further the plant has an environmental management plan as a part of a certified ISO 9001 quality management system, meeting the requirement of BEP.

Fact sheet Single Projects under 14/CP.7

Name of the single project	Century aluminium – establishment of aluminium plant
Name of the company/production facility	Century Aluminium
Location of the project	Grundartanga, 301 Akranes, Iceland
NIR category	2.C.3 Aluminium production
Description of the industrial process facility	Aluminium production started at the Century Aluminium plant at Grundartangi in 1998. The plant consisted in the beginning of one potline. In 2001 a second potline was taken into operation. In 2006 a further expansion of the plant took place. The process used in all potlines is PFPB with automatic multiple point feed.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Aluminium production plant at Grundartangi and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2172 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	- Iceland's total CO2 emissions for 1990 were 2172 Gg (according to Iceland's Initial Report under the Kyoto Protocol). - total industrial CO_2 emissions from the project in 2008 were 402 Gg or 18,5% of the 1990 CO_2 emissions. - this is higher than the 5% threshold in paragraph 2.
Reporting of CO2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2008 to 273,845 tonnes of aluminium. The resulting CO_2 emissions are 402 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in 2008 is thus 1.47 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and paragraph 5.	Century Aluminium uses LPG and gasoil for heating of melting pots. In 2008 the total fuel consumption was 370 tonnes of gasoil and 280 tonnes of LPG leading to emissions of 2.0 Gg of GHG. The EF for gasoil is 3.18 t CO_2 eq per tonne of fuel. The EF for LPG is 2.95 t CO_2 eq per tonne of fuel. The IEF for energy use is 0.007 t CO_2 eq per tonne of aluminium. These emissions are reported in the Energy sector. In 2008 the total use of electricity was 4,041 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 13.2 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 53 Gg. Had the energy been from coal powered power plant the per kWh emissions would amount to approximately 954 g. The resulting emissions from the project would thus have amounted to 3855 Gg. The resulting emissions savings are 3082 Gg
Provide evidence that the project fulfils paragraph 2.(c)	As stipulated in the operating permit for Century Aluminium plant at Grundartangi, BAT as defined by the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is applied at the plant. Century Aluminium is preparing implementation of an environmental management system according to ISO 14001.

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

Fact sheet Single Projects under 14/CP.7

Name of the single project	Alcoa Fjarðaál – establishment of aluminium plant
Name of the company/production facility	Alcoa Fjarðaál
Location of the project	Reyðarfjörður, Iceland
NIR category	2.C.3 Aluminium production
Description of the industrial process facility	Aluminium production started at the Alcoa Fjarðaál plant at Reyðarfjörður in 2007. In 2008 the plant reached full production capacity of 346,000 tonnes of aluminium. The process used in all potlines is PFPB with automatic multiple point feed.
Evidence that the projects fulfils paragraph 1[#]	The Environment Agency of Iceland issues Operating licences for the Aluminium production plant in Reyðarfjörður and is responsible for the supervision of the plant. Statistics on production is supplied to the Agency each year. See also description previously in this annex.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2172 Gg. Total 1990 CO_2 emissions from all Annex I Parties amounted to 13,728,306 Gg*. Iceland's CO_2 emissions are thus 0.016% of the Annex I Parties total, calculated in accordance with the table contained in the annex to document FCCC/CP/1997/7/Add.1 This is lower than the 0.05% threshold in paragraph 2(a).
Provide evidence that the selected project fulfils paragraph 2	- Iceland's total CO_2 emissions for 1990 were 2172 Gg (according to Iceland's Initial Report under the Kyoto Protocol). - total industrial CO_2 emissions from the project in 2008 were 491 Gg or 22,6% the 1990 CO_2 emissions. - this is higher than the 5% threshold in paragraph 2.
Reporting of CO2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2008 to 319,929 tonnes of aluminium. The resulting CO_2 emissions are 491 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the emission factors from the IPCC Guidelines. The implied emission factor in 2008 is thus 1.53 t CO_2 per tonne of aluminium. QA/QC procedures include collecting activity data through electronic surveys allowing immediate QC-check on IEF. More information is in the QA/QC Manual.
Provide evidence that the project fulfils paragraph 2.(b) and paragraph 5.	Alcoa Fjarðaál uses LPG and gasoil for heating of melting pots. In 2008 the total fuel consumption was 469 tonnes of gasoil and 453 tonnes of LPG leading to emissions of 2.8 Gg of GHG. The EF for gasoil is 3.18 t CO_2 eq per tonne of fuel. The EF for LPG is 2.95 t CO_2 eq per tonne of fuel. The IEF for energy use is 0.009 t CO_2 eq per tonne of aluminium. These emissions are reported in the Energy sector. In 2008 the total use of electricity was 4,297 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 13.2 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 57 Gg. Had the energy been from coal powered power plant the per kWh emissions would amount to approximately 954 g. The resulting emissions from the project would thus have amounted to 4099 Gg. The resulting emissions savings are 4043 Gg
Provide evidence that the project fulfils paragraph 2.(c)	As stipulated in the operating permit for Alcoa Fjarðaál plant at Reyðarfjörður, BAT as defined by the IPPC, Reference Document on Best Available Techniques in the Non Ferrous Metals Industries, December 2001, is applied at the plant. Alcoa Fjarðaál is preparing implementation of an environmental management system according to ISO 14001. Further, two audits have been performed in

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7

	accordance with Alcoa´s Self Assessment Tool (ASAT). If the provisions of ASAT are met, all requirements of ISO 14001 should be met.