Emissions of greenhouse gases in Iceland from 1990 to 2011

National Inventory Report 2013

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

ENVIRONMENT AGENCY 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 2013. 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 – 2011. 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 major contributions by the Agricultural University of Iceland (AUI), Icelandic Forest Research (IFR), and the Soil Conservation Service of Iceland (SCSI).

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Definitions 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 1,000 tonnes.

Global warming potentials (GWP) of greenhouse gases.

Greenhouse gas	Chemical formula	1995 IPCC GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Sulphur hexafluoride	SF_6	23,900
Perfluorocarbons (PFCs)		
Tetrafluoromethane	CF_4	6,500
Hexafluoroethane	C_2F_6	9,200
Octafluoropropane	C_3F_8	7,000
Hydrofluorocarbons		
HFC-23	CHF_3	11,700
HFC-32	CH_2F_2	650
HFC-125	C_2HF_5	2,800
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1,300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3,800
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-227ea	C_3HF_7	2,900

Source: FCCC/CP/2002/8, p.15

Abbreviations

1996 GL	1996 IPCC Guidelines for Greenhouse Gas Inventories
2006 GL	2006 IPCC Guidelines for Greenhouse Gas Inventories
AAU	Assigned Amount Units
AUI	Agricultural University of Iceland
BAT	Best Available Technology
BEP	Best Environmental Practice
BOD	Biological Oxygen Demand
C_2F_6	Hexafluoroethane
C_3F_8	Octafluoropropane
CER	Certified Emission Unit
CF_4	Tetrafluoromethane
CFC	Chlorofluorocarbon
CH_4	Methane
CITL	Community Independent Transaction Log
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2-eq	Carbon Dioxide Equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CRF	Common Reporting Format
DOC	Degradable Organic Carbon
EA	The Environment Agency of Iceland
EF	Emission Factor
ERT	Expert Review Team
ERU	Emission Reduction Unit
EU ETS	European Union Greenhouse Gas Emission Trading System
FAI	Farmers Association of Iceland
FeSi	Ferrosilicon
FRL	Farmers Revegetate the Land
GDP	Gross Domestic Product
Gg	Gigagrams
GHG	Greenhouse Gases
GIS	Geographic Information System
GPG	IPCC Good Practice Guidance in National Greenhouse Gas Inventories
GPS	Global Positioning System
GRETA	Greenhouse gases Registry for Emissions Trading Arrangements
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbon
IEF	Implied Emission Factor
IFR	Icelandic Forest Research
IFS	Iceland Forest Service
IFVA	Icelandic Food and Veterinary Association
IPCC	Intergovernmental Panel on Climate Change
ITL	International Transaction Log
IW	Industrial Waste
Kha	Kilohectare

Table continued	
KP	Kyoto Protocol
LULUCF	Land Use, Land-Use Change and Forestry
MAC	Mobile Air Conditioning
MAC	Mobile Air-Conditioning Systems
MCF	Methane Correction Factor
MSW	Municipal Solid Waste
N_2O	Nitrogen Dioxide
NEA	National Energy Authority
NFI	National Forest Inventory
NIR	National Inventory Report
NIRA	The National Inventory on Revegetation Area
NMVOC	Non-Methane Volatile Organic Compounds
NNFI	New National Forest Inventory
NOx	Nitrogen Oxides
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
OX	Oxidation Factor
PFC	Perfluorocarbons
QA/QC	Quality Assurance/Quality Control
RMU	Removal Unit
SCSI	Soil Conservation Service of Iceland
SEF	Standard Electronic Format
SF_6	Sulfur Hexafluoride
Si	Silicon
SiO	Silicon Monoxide
SiO_2	Quarts
SO_2	Sulfur Dioxide
SO_2-eq	Sulfur Dioxide Equivalents
SSPP	Systematic sampling of permanent plots
SWD	Solid Waste Disposal
SWDS	Solid Waste Disposal Sites
t/t	Tonne per Tonne
TOW	Total Organics in Wastewater
UNFCCC	United Nations Framework Convention on Climate Changes

EXECUTIVE SUMMARY

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, IPCC Good Practice Guidance for LULUCF the Revised 1996 Guidelines, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, 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 Land use, Land use change and forestry (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 through 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. An Action plan for climate change mitigation was adopted in 2010. The Action Plan builds on an expert study on mitigation potential and cost from 2009 and takes account of the 2007 climate change strategy and likely international commitments. In 2012 the first yearly progress report was published, where the emissions and removals are compared with the goals put forward in the Action plan.

A carbon tax was introduced in 2009. In 2010 a bill on excise tax on vehicles was adopted; Act. 156/2010. The aim of these Acts is coordination of taxation of vehicles and fuels, with the objective to promote the use of environment-friendly vehicles, energy efficiency, reduced emissions and increased use of domestic energy sources. The government recently announced its intention to participate in a joint effort with the European Union to cut emissions by 30% in 2020, compared to 1990 levels, in the context of a robust new international climate agreement. Iceland is part of the EU´s Emission Trading System, which will become a significant part of Iceland's mitigation profile in the coming years, with the inclusion of aviation, aluminium and ferrosilicon production in the ETS.

The Kyoto Protocol commits Annex I Parties to individual, legally binding targets for their greenhouse gas emissions during the first commitment period. 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.
- Decision 14/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 3,508 Gg of CO_2-equivalents. In 2011, total emissions were 4,413 Gg CO_2-equivalents. This is an increase of 26% over the time period.

A summary of the Icelandic national emissions for 1990, 2008, 2009, 2010, and 2011 is presented in *Table ES 1* (without LULUCF). Empty cells indicate emissions not occurring.

Table ES 1. Emissions of greenhouse gases during 1990, 2008, 2009, 2010, and 2011 in Gg CO_2-equivalents (excluding LULUCF).

	1990	2008	2009	2010	2011	Changes ´90-´11	Changes ´10-´11
CO_2	2,160	3,605	3,572	3,432	3,333	54.3%	-2.9%
CH_4	406	461	459	459	444	9.4%	-3.3%
N_2O	521	504	469	454	448	-13.9%	-1.2%
HFCs	NO	71	95	123	121		-1.0%
PFCs	420	349	153	146	63	-84.9%	-56.6%
SF_6	1	3	3	5	3	172.3%	-36.0%
Total emissions	3,508	4,994	4,751	4,618	4,413	25.8%	-4.4%
CO_2 emissions fulfilling 14/CP.7*		**1,177**	**1,201**	**1,229**	**1,209**		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,817**	**3,550**	**3,389**	**3,204**		

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

The largest contributor of greenhouse gas emissions in Iceland in 2011 were Industrial Processes, followed by the Energy sector, then Agriculture, Waste, and Solvent and other Product Use (Table ES 2). From 1990 to 2011, the contribution of Industrial Processes increased from 25% to 41%, emissions from the Energy sector decreased from 51% to 40% during the same period.

Table ES 2. Total emissions of greenhouse gases by source 1990, 2008, 2009, 2010, and 2011 in Gg CO_2-eqivalents.

	1990	2008	2009	2010	2011	Changes ´90-´11	Changes ´10-´11
Energy	1,779	2,075	2,021	1,869	1,770	-0.5%	-5.3%
Industrial Processes	869	2,020	1,861	1,890	1,799	106.9%	-4.8%
Emissions fulfilling 14/CP.7		1,177	1,201	1,229	1,209		-1.6%
Solvent and Other Product Use	9	7	6	6	6	-30.5%	2.5%
Agriculture	706	676	651	643	641	-9.3%	-0.3%
LULUCF	1,171	859	835	796	746	-36.3%	-6.2%
Waste	145	216	211	210	198	36.8%	-5.7%
Total emissions without LULUCF	3,508	4,994	4,751	4,618	4,413	25.8%	-4.4%
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		3,817	3,550	3,389	3,204		-5.5%
Removals from KP 3.3 and 3.4		256	275	302	337		1.4%

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

The distribution of total greenhouse gas emissions over the UNFCCC sectors (dissecting the energy sector into fuel combustion and geothermal energy and excluding LULUCF) in 2011 is shown in Figure ES 1. Emissions from the Energy sector account for 40% (fuel combustion 36% and geothermal energy 4%) of the national total emissions, industrial processes account for 41% and agriculture for 14.5%. The Waste sector accounts for 4.5%, and Solvent and other Product Use for 0.1%.

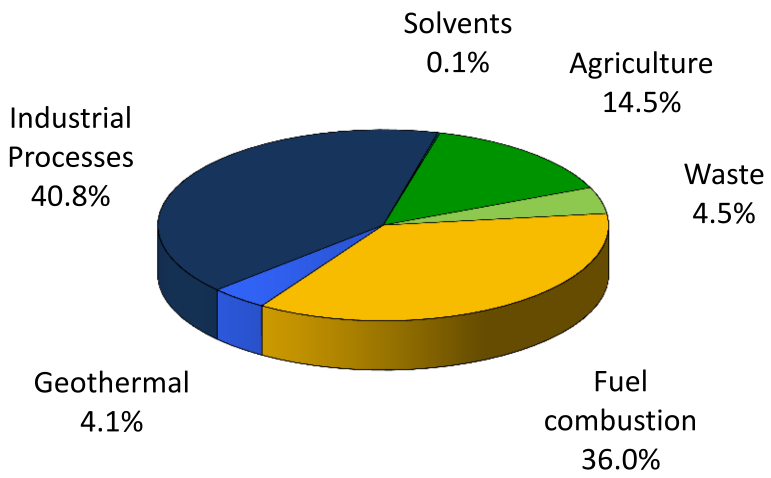

Figure ES 1. Emissions of greenhouse gases by UNFCCC sector in 2011.

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. Iceland's total Annex A greenhouse gas emissions were estimated at 4,994 Gg CO_2-equivalents for 2008, 4,751 Gg CO_2-equivalents in 2009, 4,618 Gg CO_2-equivalents in 2010, and 4,413 Gg CO_2-equivalents in 2011. Iceland's total emissions in 2011 were 26% above 1990 levels. Emissions that fall under the provision of Decision 14/CP.7 amounted to 1177 Gg CO_2 in 2008, 1201 Gg CO_2 in 2009, 1229 in 2010 and 1209 Gg CO_2 in 2011. 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. Activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol amounted to 256 Gg in 2008, 275 Gg in 2009, 302 Gg in 2010 and 337 Gg CO_2-equivalents in 2011. Assuming the removals under Article 3.3 and 3.4 would be the same in 2012 as in 2011, a total of 1,506,501 RMUs could be issued for the first commitment period. Adding these removal units to Iceland's initial assigned amount would therefore result in total of 20,030,348 units on the assigned amount side. Assuming Iceland's emissions in 2012 would be the average of the emissions in the period 2008 to 2012, the total emissions in the period would be 23,469,781 tonnes of CO_2 equivalents. This would mean that only 3439 Gg of the emissions fulfilling the provisions of Decision 14/CP.7 would be reported separately and not be included in national totals.

Iceland did not submit the Standard Electronic Format (SEF) as Iceland has not transferred or acquired any Kyoto Protocol Units.

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 first commitment period. 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. 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. In November 2010, the Icelandic government adopted a Climate Change Action Plan in order to execute the strategy (Ministry for the Environment, 2010). The action plan proposes 10 major tasks to curb and reduce GHG emissions in six sectors, as well as provisions to increase carbon sequestration resulting from afforestation and revegetation programs. The main tasks are:

A. Implementing the EU Emission Trading Scheme (ETS)
B. Implementing carbon emission charge on fuel for domestic use
C. Changing of tax systems and fees on cars and fuel

D. Enhance the use of environmentally-friendly vehicles at governmental and municipality bodies
E. Promote alternative transport methods like walking, cycling, and public transport
F. Use of biofuel in the fishing fleet
G. Using electricity as an energy resource in the fishmeal industry
H. Increase afforestation and revegetation
I. Restoring wetlands
J. Increase research and innovation climate issues

In 2012 the first yearly progress report was published, where the emissions and removals are compared with the goals put forward in the Action plan.

In 2009 a bill on taxation of fuels was adopted; Act. 129/2009. In 2010 a bill on excise tax on vehicles was adopted; Act. 156/2010. The aim of these Acts is coordination of taxation of vehicles and fuels, with the objective to promote the use of environment-friendly vehicles, energy efficiency, reduced emissions and increased use of domestic energy sources. The government recently announced its intention to participate in a joint effort with the European Union to cut emissions by 30% in 2020, compared to 1990 levels, in the context of a robust new international climate agreement. Iceland is part of the EU´s Emission Trading System, which will become a significant part of Iceland‘s mitigation profile in the coming years, with the inclusion of aviation, aluminium and ferrosilicon production in the ETS.

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 to the use of renewable energy sources (geothermal and hydropower). Second, almost 80% of emissions from the Energy sector stem from mobile sources (transport, mobile machinery and commercial 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 aluminium 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 the question 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 8 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 (BEP) and best available technology (BAT) 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 cannot 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 projects, from which emissions fulfil the provisions of Decision 14/CP.7, are described in Chapter 4.5 and Fact sheets for the project can be found in Annex IV.

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 1990-2011. The methodologies 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 NO_x, 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 auspices of the Ministry for the Environment and Natural Resources, 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.

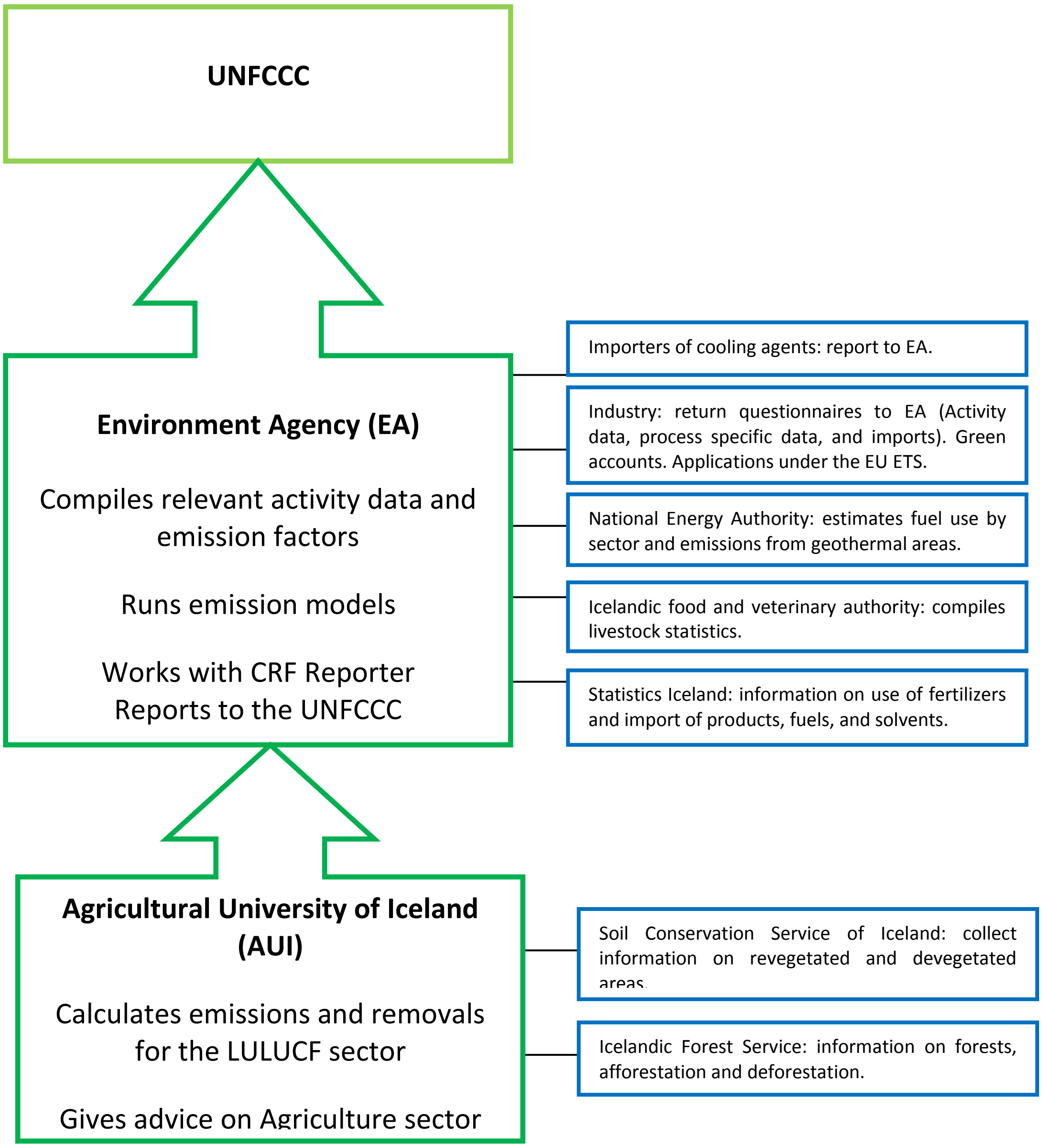

Figure 1.1. Information flow and distribution of responsibilities in the Icelandic emission inventory system for reporting to the UNFCCC.

A Coordinating Team was established in 2008 as a part of the national system and operated until 2012. The team had representatives from the Ministry for the Environment, the EA and the AUI not directly involved in preparing the inventory. Its official roles was 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 each inventory cycle in the period 2008 to 2012 the Coordinating Team held several meetings, of which some meetings were only with the Coordinating Team's members and other meetings were held with the team members as well as major data providers. The work of the team 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 also incorporated into the inventory. The Coordinating Team ceased to operate in 2012 when a new Act no. 70/2012 on climate change was passed by the Icelandic legislature Althingi.

1.2.2 Act No. 70 from 2012

In June 2012 the Icelandic Parliament passed a new law on climate change (Act 70/2012). The objectives of the Act are:

- reducing greenhouse gas emissions efficiently and effectively,
- to increase carbon sequestration from the atmosphere,
- promoting mitigation to the consequences of climate change, and
- to create conditions for the government to fulfil its international obligations regarding climate change.

The law supersedes Act 65/2007 on which basis the Environment Agency made formal agreements with the necessary collaborating agencies involved in the preparation of the inventory to cover responsibilities such as data collection and methodologies, data delivery timeliness and uncertainty estimates. The data collection for this submission is based on these agreements. Articles 7 to 15 of Act 65/2007 regarding the allocation of allowances in the period 2008 to 2012 still stands. Regulation 244/2009, put forward on basis of Act 65/2007 further elaborates on the reporting of information from the industrial plants falling under that part of Act 65/2007. Based on Act 65/2007 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, allocated emissions allowance for operators falling within the scope of the Act during the period 1 January 2008 to 31 December 2012 (see Chapter 4.5).

Act 70/2012 establishes the national system for the estimation of greenhouse gas emissions by sources and removals by sinks, a national registry, emission permits and establishes the legal basis for installations and aviation operators participating in the EU ETS. 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.

Paragraph 6 of Act 70/2012 addresses Iceland´s greenhouse gas inventory. It states that the Environment Agency (EA) compiles Iceland´s GHG inventory in accordance with Iceland´s international obligations. Act 70/2012 changes the form of relations between the EA and other bodies concerning data handling. The law states that the following institutions are obligated to collect data necessary for the GHG inventory and report it to the EA, further to be elaborated in regulations set by the Minister for the Environment and Natural Resources:

- Soil Conservation Service of Iceland (SCSI)
- Iceland Forest Service (IFS)
- National Energy Authority (NEA)
- Agricultural University of Iceland (AUI)
- Iceland Food and Veterinary Authority
- Statistics Iceland
- The Road Traffic Directorate
- The Icelandic Recycling Fund
- Directorate of Customs

The relevant regulation regarding manner and deadlines of said data is in preparation; a first order draft is in place. The regulation will be in place for the next inventory cycle. It is foreseen that the new law will facilitate the responsibilities, the data collection process and the timeliness.

As the prospective regulation on data collection, based on Act 70/2012, formalizes the cooperation and data collection process between the EA and all responsible institutions, it takes over the role of the Coordinating Team as regards the cooperation between different institutions. The role of the Coordinating Team as regards the review will be done through external review according to prioritization plan. The external review will focus on key sources and categories where methodological changes have taken place. Further all chapters of the inventory will be reviewed on periodic basis. Internal review within the EA, involving experts not directly involved in the preparation of the GHG inventory, will continue.

1.2.3 Green Accounts

According to Icelandic Regulation No. 851/2002 on green accounting, industry is required to hold, and to publish annually, information on how environmental issues are handled, the amount of raw material and energy consumed, the amount of discharged pollutants, including greenhouse gas emissions, and waste generated. Emissions reported by installations have to be verified by independent auditors, who need to sign the reports before their submission to the Environment Agency. The green accounts are then made publicly available at the website of the EA.

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. From 2008 and onwards, Act No. 48/2007 enables the NEA to obtain sales statistics from the oil companies. Until 2011 the Farmers Association of Iceland (FAI), on behalf of the Ministry of Agriculture, was responsible for assessing the size of the animal population each year, when the Food and Veterinary Authority took over that responsibility. On request from the EA, the FAI assisted to come up with a method to account for young animals that are mostly excluded from national statistics on animal population. Animal statistics have been further developed to better account for replacement animals in accordance with recommendations from the ERT that came to Iceland for an in-country review in 2011. Statistics Iceland provides information on population, GDP, production of asphalt, food and beverages, imports of solvents and other products, the import of fertilizers and on the import and export of fuels. The EA collects various additional data directly. Annually an electronic questionnaire on imports, use of feedstock, and production and process specific information is sent out to industrial producers, in accordance with Regulation no. 244/2009. Green Accounts submitted under Regulation no. 851/2002 from the industry are also used. For this submission the data contained in applications for free allowances under the EU ETS is also used. Importers of HFCs submit reports on their annual imports by type of HFCs to the EA. The Icelandic Directorate of Customs supplies the EA with information on the identity of importers of open and closed-cell foam. The 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, IPCCC Good Practice Guidance for LULUCF, and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, since limited information is available from measurements of emissions in Iceland.

The 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. The 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.

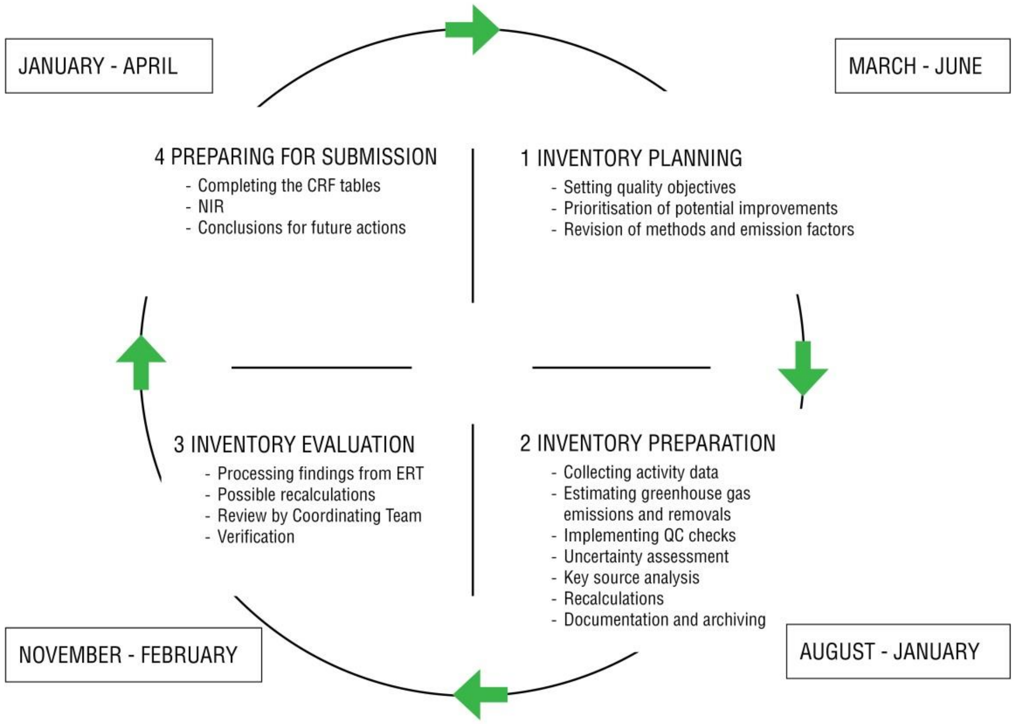

Figure 1.2. The annual inventory cycle.

A new annual cycle begins with an initial planning of activities for the inventory cycle by the inventory team and major data providers as needed (NEA, AUI, IFS and SCSI), taking into account the outcome of the internal and external review as well as 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 an approval by the director and the inventory team at the EA, the greenhouse gas inventory is submitted to the UNFCCC by the 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 NO_x, 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 Archiving

GoPro, a document management system running on a Lotus Domino server, is used to store email communications concerning the GHG inventory. Paper documents, e.g. written letters, are scanned and also stored in GoPro. Numerical data, calculations and other related documents are stored on a Windows 2003 file server. Both the Lotus Domino server and the Windows 2003 server are running as Vmware virtual machines on Dell Blade Servers. These servers are hosted by an external IT company called Advania and their server room is located elsewhere in Reykjavik. Daily backups are taken of all the servers and separate copies of the backups are stored off-site in a neighbouring town called Hafnarfjordur. Hard copies of all references listed in the NIR are stored in the EA. The archiving process has improved over the last years, i.e. the origin of data dating years back cannot always be found out. The land use database IGLUD is stored on a server of the Agricultural University of Iceland (AUI). All other data used in LULUCF as well as spread sheets containing calculations are stored there as well. This excludes data regarding Forestry and Revegetation which is stored on servers of the Icelandic Forestry Service and Soil Conservation Service of Iceland, respectively.

1.6 Key source Categories

According to 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.

The results of the key source analysis prepared for the 2013 submission are shown in Table 1.1. Tables showing the key source analysis (trend and level assessment) can be found in Annex I. The key source analysis includes LULUCF greenhouse gas sources and sinks.

Table 1.1. Key source categories of Iceland´s 2013 GHG inventory.

IPCC source category			Level 1990	Level 2011	Trend
1. Energy					
1.AA.1	Public electricity and heat production	CH_4			
1.AA.1	Public electricity and heat production	CO_2			
1.AA.1	Public electricity and heat production	N_2O			
1.AA.2	Manufacturing industry and construction	CH_4			
1.AA.2	Manufacturing industry and construction	CO_2	✓	✓	✓
1.AA.2	Manufacturing industry and construction	N_2O			
1.AA.3a/d	Transport	CH_4			
1.AA.3a/d	Transport	CO_2	✓		✓
1.AA.3a/d	Transport	N_2O			
1.AA.3b	Road transport	CH_4			
1.AA.3b	Road transport	CO_2	✓	✓	✓
1.AA.3b	Road transport	N_2O			✓
1.AA.4a/b	Residential/institutional/commercial	CH_4			
1.AA.4a/b	Residential/institutional/commercial	CO_2			
1.AA.4a/b	Residential/institutional/commercial	N_2O			
1.AA.4c	Fishing	CH_4			
1.AA.4c	Fishing	CO_2	✓	✓	✓
1.AA.4c	Fishing	N_2O			
1.B.2	Geothermal energy	CH_4			
1.B.2	Geothermal energy	CO_2	✓	✓	✓
2. Industrial Processes					
2.A	Mineral production	CO_2	✓		✓
2.B	Chemical industry	CO_2			
2.B	Chemical industry	N_2O	✓		
2.C	Metal production	CH_4			
2.C.2	Ferroalloys	CO_2	✓	✓	✓
2.C.3	Aluminium	CO_2	✓	✓	✓
2.C.3	Aluminium	PFC	✓	✓	✓
2.F	Consumption of halocarbons and SF6, refrigeration	HFC		✓	✓
2.F	Consumption of halocarbons and SF6, refrigeration	PFC			
2.F	Consumption of halocarbons and SF6, electrical	SF_6			
3. Solvents and Other Product Use					
3	Solvent and other product use	CO_2			
3	Solvent and other product use	N_2O			
4. Agriculture					
4.A.1	Enteric fermentation, cattle	CH_4	✓	✓	
4.A.3	Enteric fermentation, sheep	CH_4	✓	✓	✓

Table 1.1. continued					
IPCC source category			Level 1990	Level 2011	Trend
4.A.4-10	Enteric fermentation, rest	CH_4			
4.B	Manure management	CH_4			
4.B	Manure management	N_2O	✓	✓	
4.D.1	Direct soil emissions	N_2O	✓	✓	✓
4.D.2	Animal production	N_2O	✓	✓	
4.D.3	Indirect soil emissions	N_2O	✓	✓	
5. Land use, Land use change and Forestry					
5.A	Forest land - Afforestation	CO_2		✓	✓
5.A	Forest land - Natural birch forest	CO_2		✓	
5.A	Forest land - Afforestation	N_2O			
5.B.1	Cropland remaining Cropland	CO_2	✓	✓	✓
5.B.2	Land converted to Cropland	CO_2	✓	✓	✓
5.C.1	Wetland drained for more than 20 years	CO_2	✓	✓	✓
5.C.1	All other remaining Grassland	CO_2			
5.C.1	Grassland remaining grassland, biomass burning	CO_2			
5.C.1	Grassland remaining grassland, biomass burning	CH_4			
5.C.2.1-4	All other conversion to Grassland	CO_2	✓	✓	✓
5.C.2.5	Other land converted to Grassland, revegetation	CO_2	✓	✓	✓
5.D	Wetlands	CH_4			
5.D	Wetlands	CO_2			
5.D	Wetlands	N_2O			
5.E.2.1	Settlements	CO_2			
5.G	Grassland non CO2-emissions	N_2O	✓	✓	
6. Waste					
6.A.1	Managed waste disposal on land	CH_4		✓	✓
6.A2	Unmanaged waste disposal sites	CH_4	✓		✓
6.B	Wastewater handling	CH_4			
6.B	Wastewater handling	N_2O			
6.C	Waste incineration	CH_4			
6.C	Waste incineration	CO_2			
6.C	Waste incineration	N_2O			
6.D	Other (composting)	CH_4			
6.D	Other (composting)	N_2O			

1.7 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 and can be found at ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_plan.pdf. The document describes the quality assurance and quality control programme. It includes the quality objectives and an inventory quality assurance and quality control plan. It also describes the responsibilities and the time schedule for the performance of QA/QC procedures. The QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Source category specific QC measures have been developed for several key source categories.

A quality manual for the Icelandic emission inventory has been prepared (ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/Iceland_QAQC_manual.pdf). To further facilitate the QA/QC procedures all calculation sheets have been revised. They 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.

1.8 Uncertainty Evaluation

Uncertainty estimates are an essential element of a complete inventory and are not used to dispute the validity of the inventory but rather help prioritise efforts to improve the accuracy of the inventory. Here, the uncertainty analysis is according to the Tier 1 method of the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories where different gases are reviewed separately as CO_2-equivalents. Total base and current years´ emissions within a greenhouse gas sector, category or subcategory are used in the calculations as well as corresponding uncertainty estimate values for activity data and emission factors used in emission calculations.

Uncertainties were estimated for all greenhouse gas source and sink categories (i.e. including LULUCF) according to the IPCC Good Practice Guidance. Estimates for activity data uncertainties are mainly based on expert judgement whereas emission factor uncertainties are mainly based on IPCC source category defaults. Activity data and emission factor uncertainty estimates for the Agriculture, Waste, and Solvents sectors as well as for consumption of HFCs and SF_6 were reviewed leading to considerably higher combined uncertainty estimates for these sectors. All source category uncertainties were first weighted with 2011 emission estimates and then summarized using error propagation. This calculation yielded an overall uncertainty of the 2011 emission estimate of 33.5%. The substantial increase from the value of the 2012 submission (19.1%) is caused by the higher uncertainty estimates for the sectors mentioned above.

Uncertainty estimates introduced on the trend of greenhouse gas emission estimates by uncertainties in activity data and emission factors are combined and then summarized by error propagation to obtain the total uncertainty of the trend. This calculation yielded a total trend uncertainty of 16.7%. The increase from the value of the 2012 submission (12.1%) is also caused by the higher uncertainty estimates in the sectors mentioned above.

The results of the uncertainty estimate can be found in Annex II.

1.9 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 2011.

With regard to sectoral coverage few sources are not estimated.

The main sources not estimated are:

- Emissions of CO_2 and CH_4 from road paving with asphalt (2A6).
- In the LULUCF sector the most important estimates remaining are probably the ones regarding emissions/removals of mineral soil in few categories 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.

1.10 Planned and Implemented Improvements

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

- Emissions of CO_2 and CH_4 from distribution of oil products (1B2a v).
- Revision of CO_2 estimates from metal production. Emission estimates are based on carbon content of input materials and are plant and year specific.
- Revision of HFC emission estimates. A poll of the refrigeration sector was used to distribute refrigerants more accurately between subsource categories and estimate EFs more realistically.
- SF_6 emissions from electrical equipment were calculated with Tier 2 methodology
- Efforts in improving the area estimate for drained organic soils of grassland and its subdivisions to soil classes started in the summer of 2011 and continued in 2012.
- Land use change matrix is now presented in NIR thereby responding to ERT comment on 2012 submission.
- Several improvements for emissions and removals from Forest land such as the improvement of both area and C-stock estimates for natural birch woodland; the use of time series for biomass estimates in cultivated forests; the reporting of C-stock changes in dead wood; and improvements in reporting deforestation.

In the near future the following improvements for the inventory are planned:

- Preparation of a national energy balance. The NEA should prepare a national energy balance annually and submit to the EA. Work has already been initiated by the NEA, with the aim of producing the national energy balance within two years. The obligation of the NEA to provide national energy balance will be further elaborated in a regulation, to be set on basis of Act no 70/2012.
- Improvement of methodologies to estimate emissions from road transportation (use of COPERT).
- Move estimates of emissions from aviation to the Tier 2 methodology.
- Improvement of methodologies to estimate N_2O emissions from manure management.
- Developing a time series for the enhanced livestock population characterisation
- The division of land use into subcategories and improved time and spatial resolution of the land use information is an on-going task of the AUI.
- 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.
- Continued gathering of information on various C-pools in each land use category and application of this information to improve stock change estimates.
- Improving identification of former cropland categories and destination of abandoned cropland.
- Improvements of area estimate for different soil types under Cropland.
- Establishing reliable estimates of cropland biomass is also important and is planned in the summer 2013.
- Continued work on improving the area estimate of drained organic soils of Grassland.
- On-going national forest inventory (NFI) will further improve both estimates of Forest land area and Carbon stock changes.
- Quality assessment of C-stock changes of biomass in cultivated forest by calculation of statistical error values of the NFI.
- Similar efforts to the the NFI regarding Revegetation began in 2007. The Revegetation inventory is expected to provide improved data on carbon stock changes and the area of revegetated land in the next two years.
- Further improvement of the time series already presented.
- The provision of missing Annexes.
- Preparation of a comprehensive improvement plan.

The following improvements are under consideration:

- Develop CS emission factors for fuels.
- Develop verification procedures for various data.
- Improvement of QA/QC for LULUCF.
- 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 emissions.

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 1990-2011 are presented in the following tables and figures, expressed in terms of contribution by gas and source.

Table 2.1 presents emission figures for greenhouse gases by sector in 1990, 2008, 2009, 2010, and 2011 expressed in Gg CO_2-equivalents along with percentage changes for both time periods 1990-2011 and 2010-2011. Table 2.2 presents emission figures for all greenhouse gases by gas in 1990, 2008, 2009, 2010, and 2011 expressed in Gg CO_2-equivalents along with percentage changes for both time periods 1990-2011 and 2010-2011.

Table 2.1. Emissions of greenhouse gases by sector in Iceland during the period 1990-2011 in Gg CO_2-equivalents.

	1990	2008	2009	2010	2011	Changes ´90-´11	Changes ´10-´11
1. Energy	1,779	2,075	2,021	1,869	1,770	-0.5%	-5.3%
Fuel combustion	1,717	1,886	1,848	1,676	1,588	-7.5%	-5.3%
Geothermal	62	189	173	193	182	193.5%	-5.7%
2. Industrial Processes	869	2,020	1,861	1,890	1,799	106.9%	-4.8%
3. Solvent and Other Product Use	9	7	6	6	6	-30.5%	2.5%
4. Agriculture	706	676	651	643	641	-9.3%	-0.3%
5. Land Use, Land Use Change and Forestry	1,171	859	835	796	746	-36.3%	-6.2%
6. Waste	145	216	211	210	198	36.8%	-5.7%
Total emissions without LULUCF	3,508	4,994	4,751	4,618	4,413	25.8%	-4.4%
CO_2 emissions fulfilling 14/CP.7*		1,177	1,201	1,229	1,209		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,817**	**3,550**	**3,389**	**3,204**		

**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 1990-2011(without LULUCF) in Gg CO_2-equivalents.

	1990	2008	2009	2010	2011	Changes ´90-´11	Changes ´10-´11
CO_2	2,160	3,605	3,572	3,432	3,333	54.3%	-2.9%
CH_4	406	461	459	459	444	9.4%	-3.3%
N_2O	521	504	469	454	448	-13.9%	-1.2%
HFCs	NO	71	95	123	121		-1.0%
PFCs	420	349	153	146	63	-84.9%	-56.6%
SF_6	1	3	3	5	3	172.3%	-36.0%
Total emissions	3,508	4,994	4,751	4,618	4,413	25.8%	-4.4%
CO_2 emissions fulfilling 14/CP.7*		1,177	1,201	1,229	1,209		
Total emissions excluding CO_2 emissions fulfilling 14/CP.7*		**3,817**	**3,550**	**3,389**	**3,204**		

**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 fulfil the provisions of 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 total GHG emissions (excluding LULUCF) in Iceland were 3,508 Gg CO_2-equivalents. In 2011 total emissions were 4,413 Gg CO_2-equivalents. This is tantamount to an increase of 26% over the whole time period. Total emissions show a slight decrease between 1990 and 1994, with the exception of 1993. From 1995-1999 total emissions increased by about 5% per year, then plateau from 2000 to 2005. Between 2005 and 2008 emissions increased rapidly or by 10% per year. Since 2008 annual emissions have decreased again by on average 4% per year.

By the middle of the 1990s economic growth started to gain momentum in Iceland. Until 2007 Iceland experienced one of the highest GDP growth rates among OECD countries. In the autumn of 2008, Iceland was hit by an economic crisis when its three largest banks collapsed. The blow was particularly hard owing to the large size of the banking sector in relation to the overall economy as the sector´s worth was about ten times the annual GDP. The crisis resulted in a serious contraction of the economy followed by an increase in unemployment, a depreciation of the Icelandic króna (ISK), and a drastic increase in external debt. Private consumption contracted by 20% between 2007 and 2010. Emissions of greenhouse gases decreased from most sectors between 2008 and 2011.

The main driver behind increased emissions since 1990 has been the expansion of the metal production sector. In 1990, 87,839 tonnes of aluminium were produced in one aluminium plant in Iceland. A second aluminium plant was established in 1998 and a third one in 2007. In 2011, 806,319 tonnes of aluminium were produced in three aluminium plants. Parallel investments in increased power capacity were needed to accommodate for this nine fold increase in aluminium production. The size of these investments is large compared to the size of Iceland´s economy.

The increase in GDP since 1990 further explains the general growth in emissions as well as the fact that the Icelandic population has grown by 25% from 1990 to 2011. This has resulted in higher emissions from most sources, but in particular from transport and the construction sector. Emissions from the transport sector have risen considerably since 1990, as a larger share of the population uses private cars for their daily travel. Since 2008 fuel prices have risen significantly leading to lower emissions from the sector compared to preceding years. A knock-off effect of the increased levels of economic growth until 2007 was an increase in construction, especially 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 late 2008. Emissions from fuel combustion in the transport and construction sector decreased in 2008 by 5% compared to 2007, in 2009 by 8% compared to 2008, in 2010 by 7% compared to 2009 and in 2011 by 5% compared to 2010, because of the economic crises. The total decrease from 2007 to 2011 is therefore 23%. Emissions from Cement production have decreased by 69% since 2007 (process emissions and emissions from fuel consumption) also as a result of the economic crises and the collapse of the construction sector.

The overall increasing trend of greenhouse gas emissions until 2005 was counteracted to some extent by decreased emissions of PFCs, caused by improved technology and process control in the aluminium industry. Increased emissions due to an increase in production capacity of the aluminium industry (since 2006) led to a trend of overall increase in greenhouse gas emissions between 2006 and 2008, when emissions from the aluminium sector peaked. In 2011 total emissions from the aluminium sector were 20% lower than in 2008 due to less PFC emissions from the sector.

2.2 Emission Trends by Gas

All values in this chapter refer to Iceland´s total GHG emissions without LULUCF. As shown in Figure 2.1, the largest contributor by far to total GHG emissions is CO_2 (76%), followed by CH_4 (10%), N_2O (10%) and fluorinated gases (PFCs, HFCs, and SF_6, 4%). In the year 2011, the changes in gas emissions compared to 1990 levels for CO_2, CH_4, N_2O, and fluorinated gasses were 54%, 10%, -14%, and -55%, respectively (cf. Table 2.2, Figure 2.2 and Figure 2.3).

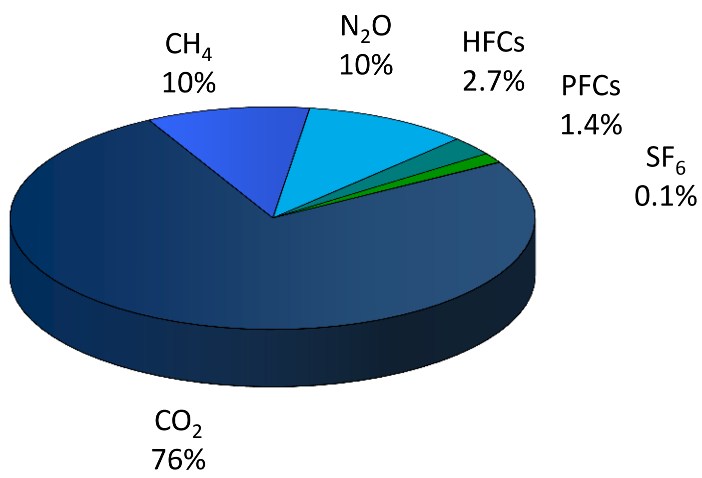

Figure 2.1. Distribution of emissions of greenhouse gases by gas in 2011.

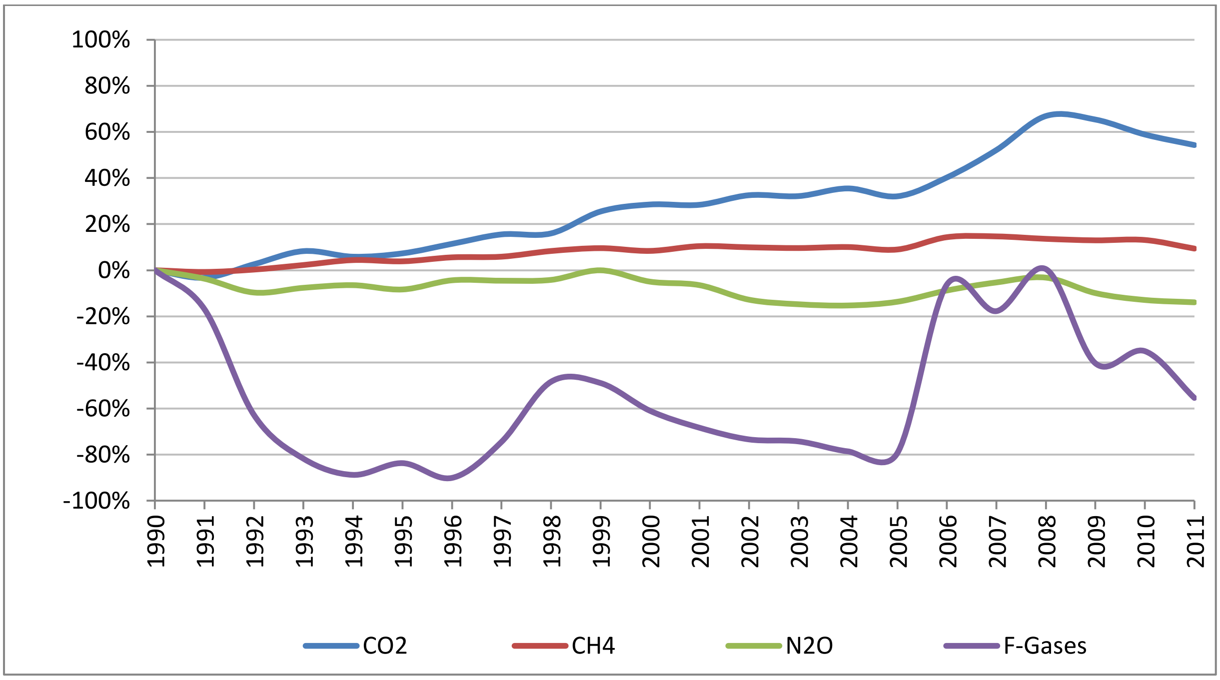

Figure 2.2. Percentage changes in emissions of GHG by gas 1990-2011, compared to 1990 levels.

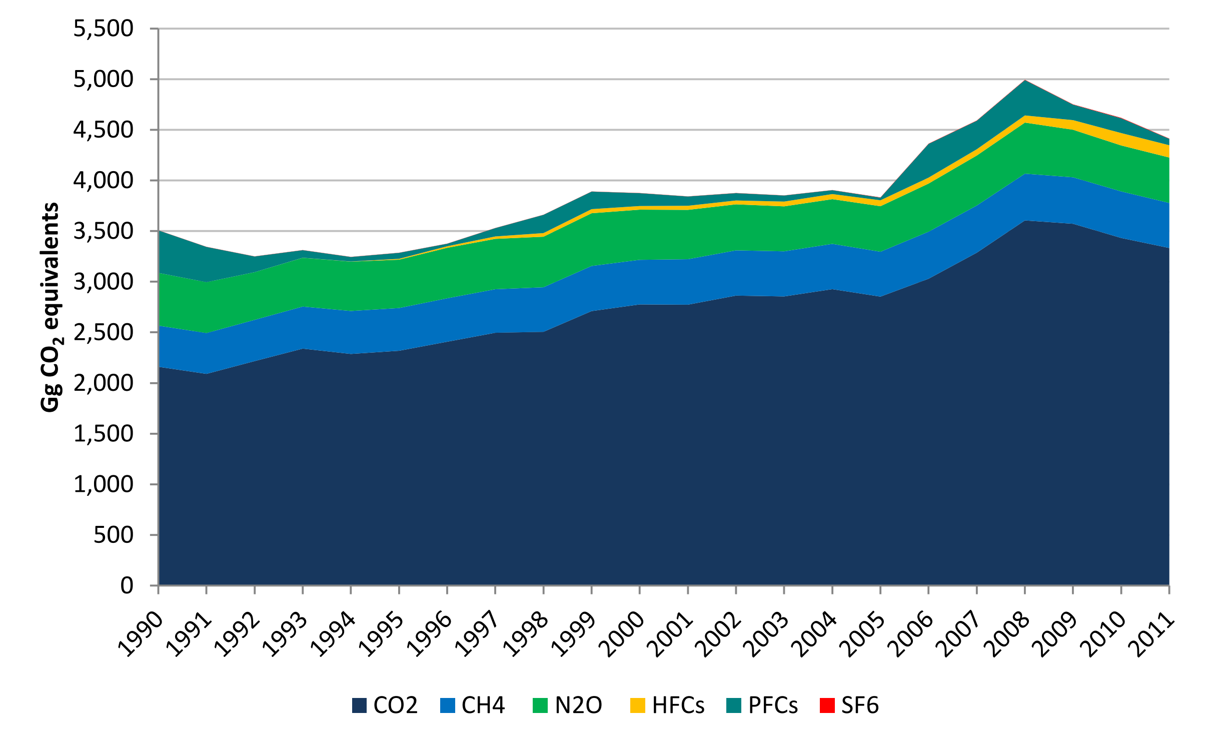

Figure 2.3. Emissions of greenhouse gases by gas, 1990-2011.

2.2.1 *Carbon Dioxide (CO2)*

Industrial processes, road transport and commercial fishing are the three main sources of CO_2 emissions in Iceland. Since emissions from 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 (though much lower since 2008 than in the years before). Emissions from geothermal energy exploitation are considerable. Other sources consist mainly of emissions from coal combustion in the cement industry, emissions from non-road transport and waste incineration. Table 2.3 lists CO_2 emissions from the main source categories for the period 1990-2011. 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 2011 compared with 1990 levels.

Table 2.3. Emissions of CO_2 by sector 1990-2011 in Gg.

	1990	1995	2000	2005	2008	2009	2010	2011
Fishing	655	772	720	626	517	597	535	500
Road vehicles	521	547	602	761	851	852	806	788
Stationary combustion, liquid fuels	243	228	214	172	109	112	97	89
Industrial processes	399	435	793	846	1,596	1,609	1,616	1,610
Construction	121	148	197	215	188	129	102	88
Geothermal	61	82	153	116	184	168	189	179
Other	159	107	97	116	160	104	88	80
Total CO_2 emissions	**2,160**	**2,318**	**2,776**	**2,853**	**3,605**	**3,572**	**3,432**	**3,333**

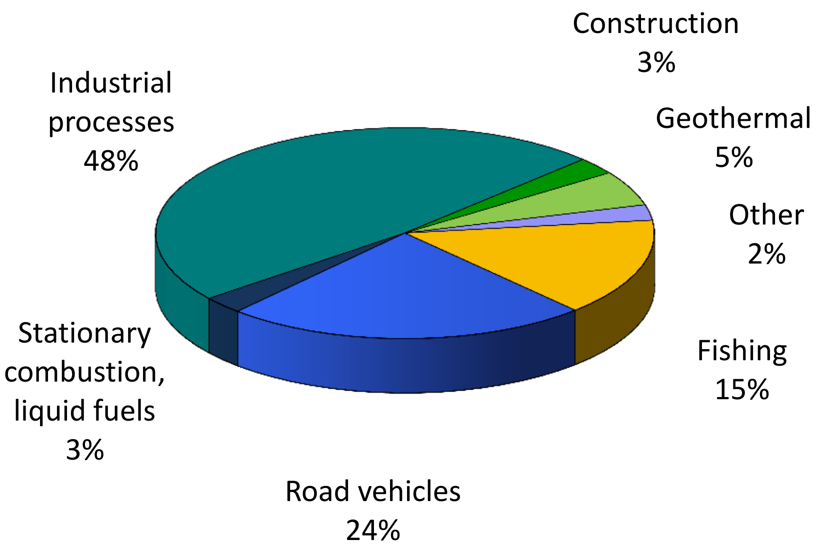

Figure 2.4. Distribution of CO_2 emissions by source in 2011.

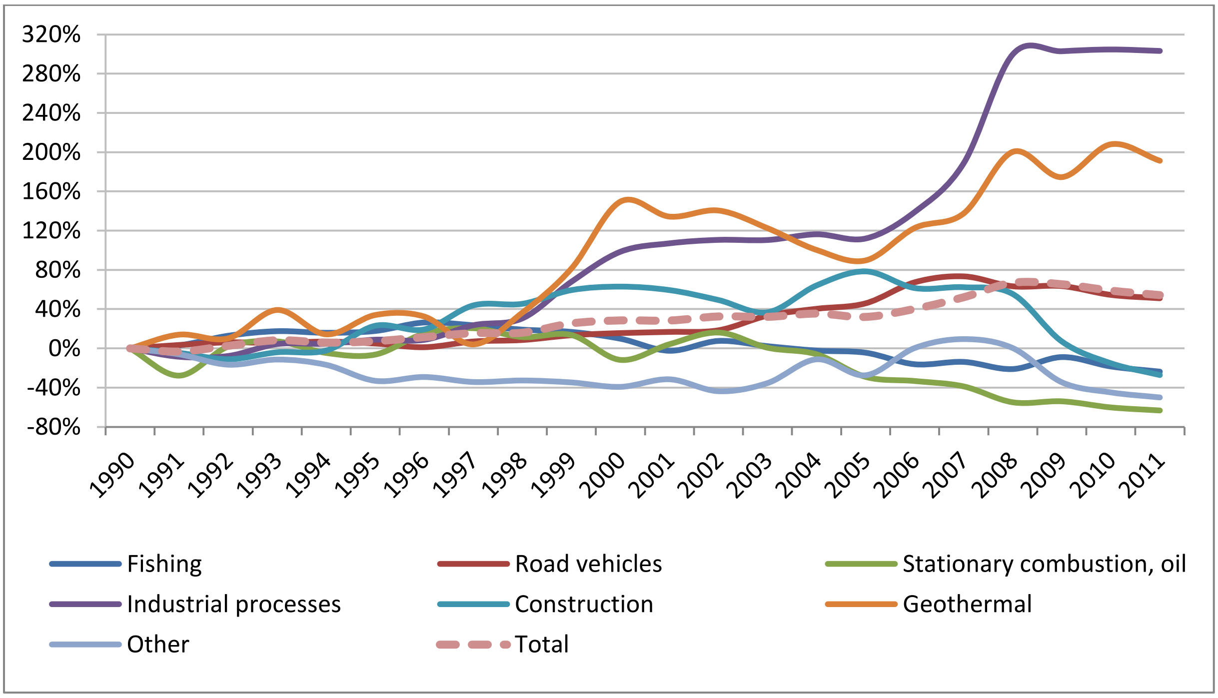

Figure 2.5. Percentage changes in emissions of CO_2 by major sources 1990-2011, compared to 1990 levels.

In 2011, Iceland´s total CO_2 emissions were 3,333 Gg. This is tantamount to an increase of 54% from 1990 levels and a decrease of about 3% from the preceding year. CO_2 emissions from industrial processes decreased by 0.4% from 2010 to 2011 due to less emissions from aluminium production, but partly counteracted by higher emissions from the cement industry and higher emission from the ferroalloys industry. Emissions from geothermal energy exploitation decreased by 5% between 2010 and 2011. Emissions from road vehicles peaked in 2007. Emissions decreased in 2008 and were 5% below the 2007 emissions but increased by 0.1% between 2008 and 2009. It is likely that the economic crisis has led to fewer air flights abroad and therefore more travel within Iceland during summer vacation. This would explain why emissions from road transport have not decreased more during 2008 and 2009 despite significantly higher fuel prices, owing to the depreciation of the Icelandic króna during the year. This can also be seen in decreased international aviation in 2008 and 2009 (Table 2.15). In 2009, 2010 and 2011 fuel prices continued to rise. In recent years more fuel economic vehicles have been imported – a turn-over of the trend from the years 2002 to 2007 when larger vehicles were imported. This can be seen in less fuel consumption in 2010 than in 2009 despite the fact that driven mileage stayed almost the same. Numbers on driven mileage in 2011 are not yet available. Emissions from stationary combustion of liquid fuels decreased by 14% from 2010 to 2011. Emissions from construction decreased by 14% and emissions from other sources decreased by 9% during the same time period.

The increase in CO_2 emissions between 1990 and 2011 can be explained by increased emissions from industrial processes (303%), road transport (51%), and geothermal energy utilisation (191%). Total CO_2 emissions from the commercial fishing and construction sectors, on the other hand, declined by 24% and 27%, respectively.

The main driver behind increased emissions from industrial processes since 1990 has been the expansion of the metal production sector, in particular the aluminium sector. In 1990, 87,839 tonnes of aluminium were produced in one aluminium plant in Iceland. A second aluminium plant was established in 1998 and a third one in 2007. In 2011, a total of 806,319 tonnes of aluminium were produced in these three aluminium plants, slightly less than in 2010.

CO_2 emissions from road transport have increased by 51% since 1990, owing to increases in population, number of cars per capita, more mileage driven, and - until 2007 - an increase in the share of larger vehicles. Since 1990 the vehicle fleet in Iceland has increased by 143%. Emissions from both domestic flights and navigation have declined since 1990.

Emissions from geothermal energy exploitation have increased by 191% since 1990. Electricity production using geothermal energy has increased from 283 GWh in 1990 to 4,701 GWh in 2011, or more than 16-fold.

Emissions from commercial 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 then increased again by 10% between 2001 and 2002, but in 2003 they dropped to 1990 levels. In 2011, the emissions were 24% below the 1990 levels and 6% below the 2010 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 at the cement plant (building time from 2002 to 2007) increased again between 2004 and 2007, although most of the cement used in this project was imported. In 2011, emissions from cement production were 67% lower than in 2007, due to the collapse of the construction sector.

2.2.2 Methane (CH_4)

Agriculture and waste treatment have been the main sources of methane emissions since 1990. In 2011 they comprised 58% and 41% of total methane emissions, respectively (Table 2.4 and Figure 2.6). The main methane source in the agriculture sector is enteric fermentation, solid waste disposal on land in the waste sector. Both accounted for roughly 90% of sector methane emissions.

Methane emissions from agriculture decreased by 6% between 1990 and 2011 due to a decrease in livestock population. Emissions from waste, on the other hand, increased by 43% during the same period. Emissions from waste treatment increased sharply from 1990 to 2007 although the amount of waste landfilled had been oscillating between 300 and 350 Gg from 1986 to 2005. The increase was due to an increasing share of waste landfilled in well managed solid waste disposal sites which are characterised by a higher methane correction factors than unmanaged sites. The decrease in methane emissions from the waste sector since 2007 is due to a decrease in the amount of waste landfilled since 2005 (Figure 2.7).

Table 2.4. Emissions of CH_4 by sector 1990-2011 (Gg CO_2-eqivalents).

	1990	1995	2000	2005	2008	2009	2010	2011
Agriculture	274	252	250	242	253	255	257	257
Waste	126	164	184	195	200	195	194	181
Other	6	6	6	6	8	9	8	7
Total	406	422	440	443	461	459	460	444

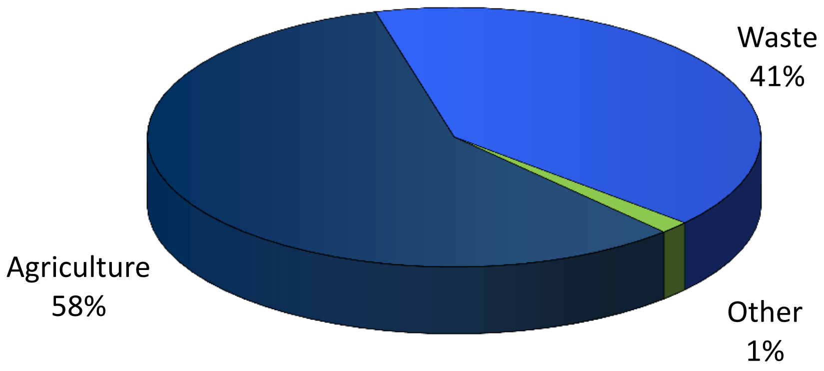

Figure 2.6. Distribution of CH_4 emissions by source in 2011.

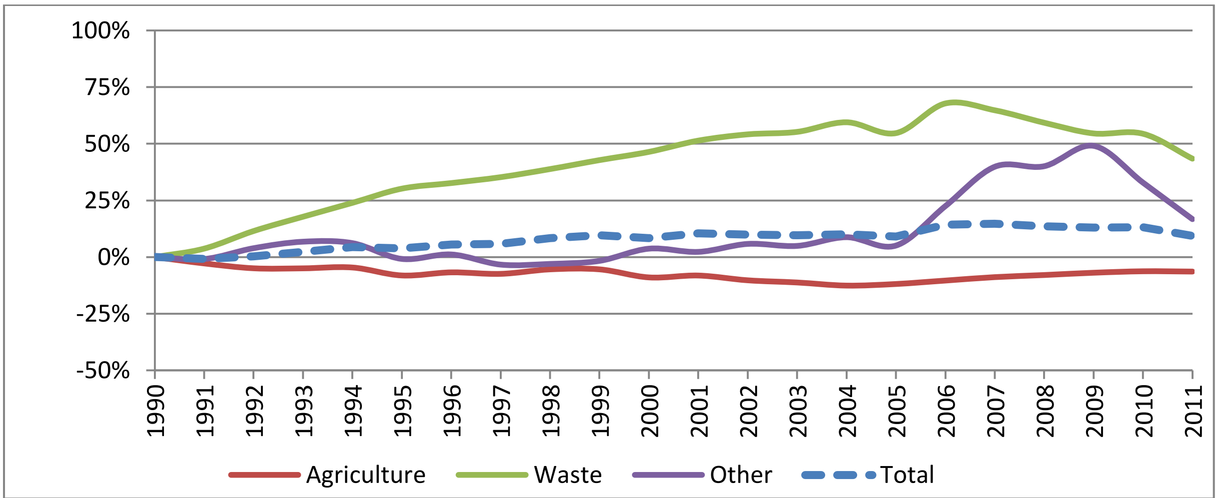

Figure 2.7. Percentage changes in emissions of CH_4 by major sources 1990-2011, compared to 1990 levels.

2.2.3 Nitrous Oxide (N_2O)

Agriculture has been the main source of N_2O emissions in Iceland and accounted for 85% of nitrous oxide emissions in 2011 (Table 2.5 and Figure 2.8). Direct and indirect N_2O emissions from agricultural soils were the most prominent emission contributors, followed by emissions from unmanaged manure and manure managed in solid storage. Emissions from the agriculture sector decreased by 11% since 1990. This development was mainly due to a decrease in livestock populations accompanied by a decrease in manure production. The second most important source of N_2O, since the shutdown of the fertilizer plant in 2001, is road transport. Emissions increased rapidly when catalytic converters became obligatory in all new vehicles in 1995. N_2O is a by-product of NO_x reduction in catalytic converters. Total nitrous oxide emissions have decreased by 14% since 1990 (Figure 2.9).

Table 2.5. Emissions of N_2O by sector 1990-2011 (Gg CO_2-equivalents).

	1990	1995	2000	2005	2008	2009	2010	2011
Agriculture	432	385	403	367	424	396	386	384
Road transport	5	12	29	38	38	38	37	35
Other fuel combustion	22	27	32	34	29	22	18	16
Chemical industry	48	42	19	NO	NO	NO	NO	NO
Other	14	12	12	11	13	13	13	13
Total	521	477	495	450	504	469	454	448

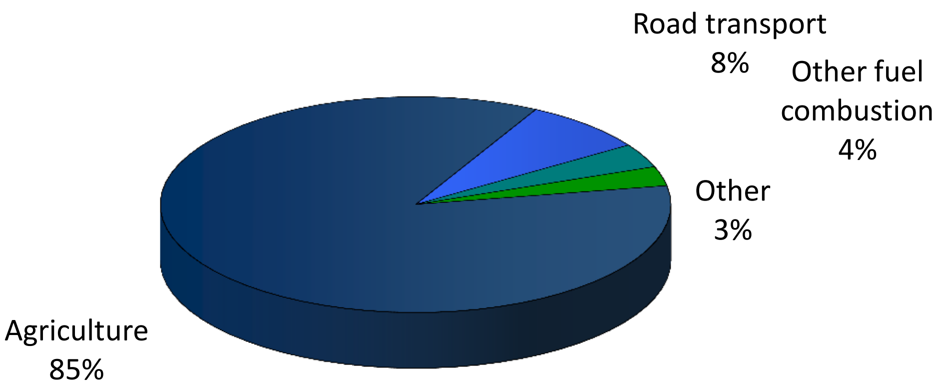

Figure 2.8. Distribution of N_2O emissions by source in 2011.

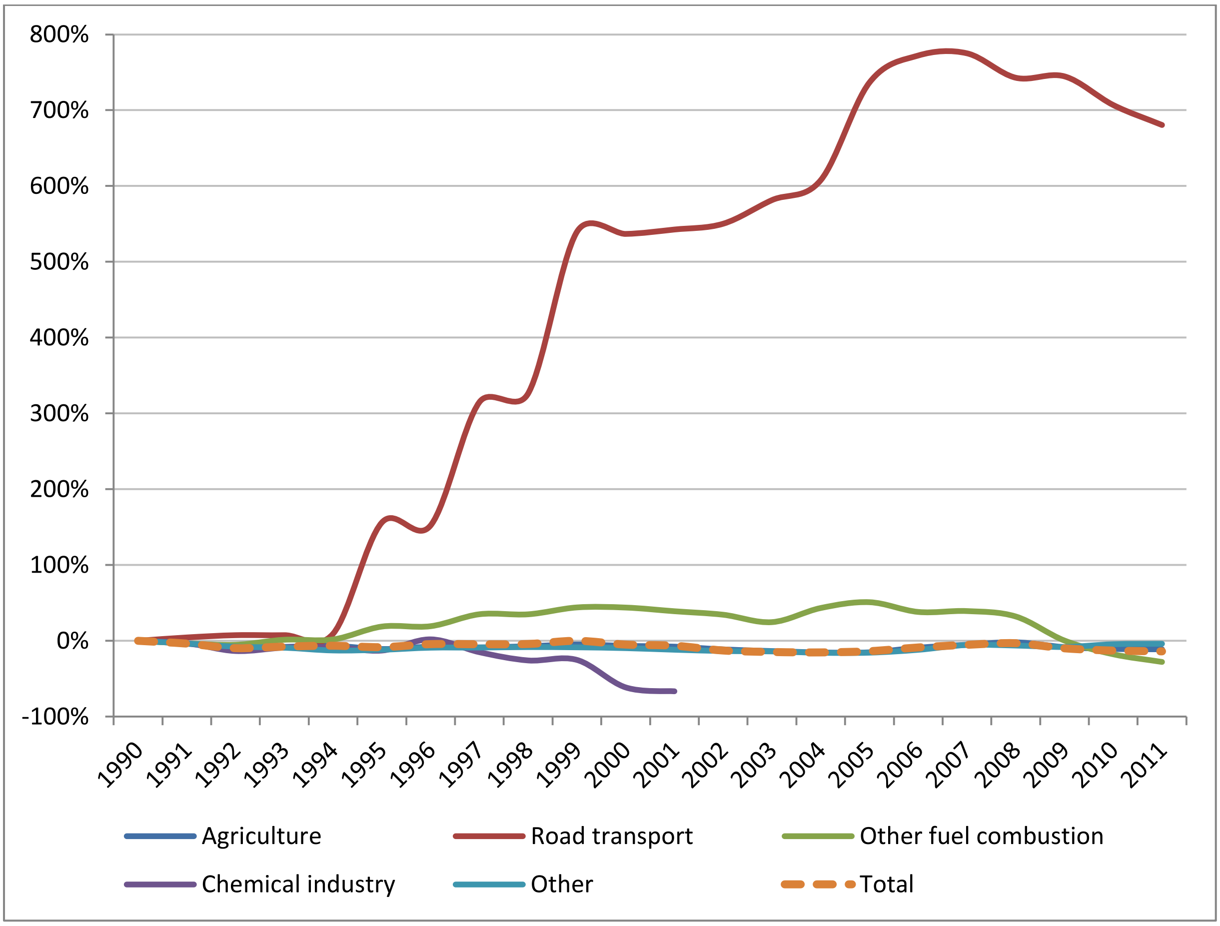

Figure 2.9. Changes in N_2O emission for major sources between 1990 and 2011.

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 53 and 10 Gg CO_2-equivalents respectively in 2011, or 63 Gg CO_2-equivalents in total. Emissions of PFCs (PFC 116 and PFC 218) from consumption of halocarbons in refrigeration and air conditioning equipment were 0.0003 Gg CO_2-equivalents in 2011 (Table 2.6).

Total PFC emissions decreased by 85% in the period of 1990-2011. The emissions decreased steadily from 1990 to 1996 with the exception of 1995, as can be seen from Figure 2.10. At that time one aluminium plant was operating in Iceland. 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 went down from 2007 to 2010 and reached 2005 levels in 2010 at the Century Aluminium plant. The Alcoa Fjarðarál aluminium plant was established in 2007 and reached full production capacity in 2008. The decline in PFC emissions in 2009, 2010 and 2011 was achieved through improved process control at both Century Aluminium plant and Alcoa Fjarðarál (except in December at Alcoa), as the processes have become more stable after a period of start-up in both plants. In December 2010 a rectifier was damaged in fire at Alcoa. This led to increased PFC emissions leading to higher emissions at the plant in 2010 than in 2009.

To a very small extent PFCs have also been used as refrigerants. C_2F_6 has been used in refrigeration and air conditioning equipment since 2002 (0.001 to 0.003 Gg CO_2-equivalents per year) and C_3F_8 was used in refrigeration and air conditioning equipment for the first time in 2009.

Table 2.6. Emissions of PFCs 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
CF_4	355	50	108	22	295	129	123	53
CF_2F_6	65	9	20	4	54	24	22	10
C_3F_8	NO	NO	NO	NO	NO	0.0006	0.0004	0.0003

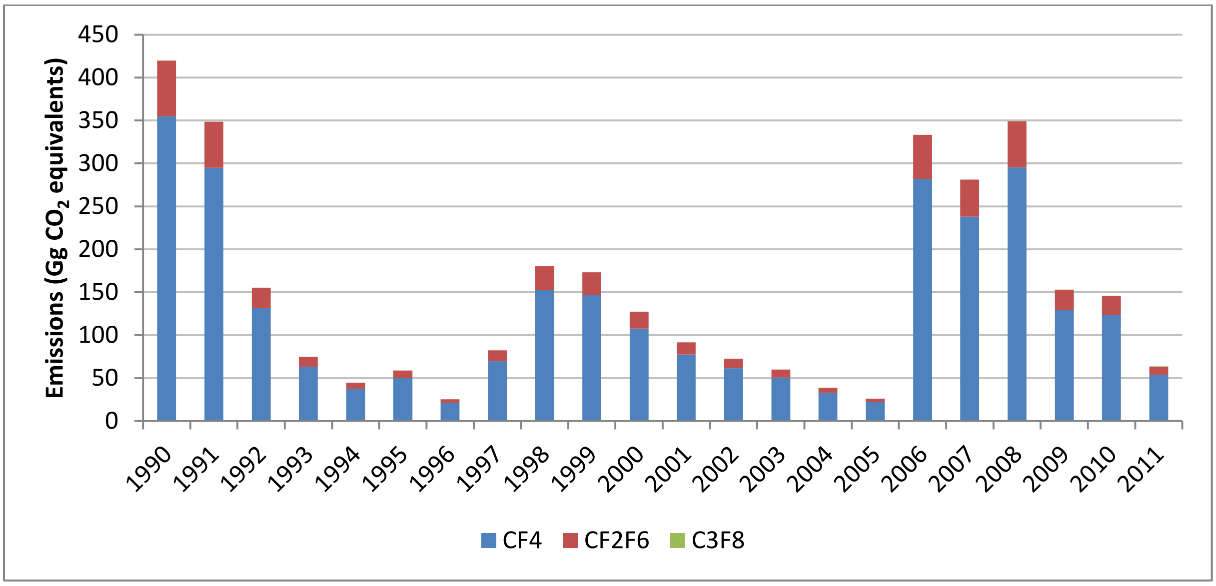

Figure 2.10. Emissions of PFCs from 1990 to 2011, Gg CO_2-equivalents.

2.2.5 Hydrofluorocarbons (HFCs)

Total actual emissions of HFCs, used as substitutes for ozone depleting substances (ODS), amounted to 121 Gg CO_2-equivalents in 2011 (Table 2.7). The import of HFCs started in 1993 and has increased until 2010 in response to the phase-out of ODS like chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). Import numbers decreased strongly in 2011, causing only a slight decrease in emissions due to the time lag between refrigerant use and leakage. Refrigeration and air-conditioning were by far the largest sources of HFC emissions and the fishing industry plays an eminent role.

Over the years, the use of ozone depleting substances (ODS) in the fishing industry has been decreasing due to restrictions on ODS import. The ban on importing new R-22, which became effective in 2010 and the impending ban on importing recovered R-22 mean a price increase for R-22 and add urgency to the process of retrofitting and replacing refrigerant systems in the fishing industry (Figure 2.11). Between 2008 and 2010 the import of HFCs had increased more than twofold.

Table 2.7. Emissions of HFCs 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
HFC 23	NO	NO	NO	0.02	0.01	0.01	0.02	0.01
HFC 32	NO	NO	0.00	0.02	0.04	0.04	0.05	0.07
HFC 125	NO	4.07	14.00	20.32	23.86	33.16	42.74	43.05
HFC 134a	NO	2.31	6.87	11.99	14.12	14.57	19.55	18.36
HFC 143a	NO	2.09	14.85	25.95	32.55	47.19	60.13	59.84
HFC 152a	NO	0.05	0.07	0.05	0.04	0.03	0.02	0.02
HFC 227ea	NO	NO	NO	0.07	0.03	0.02	0.03	0.01
Total	**NO**	**8.51**	**35.78**	**58.42**	**70.64**	**95.01**	**122.54**	**121.35**

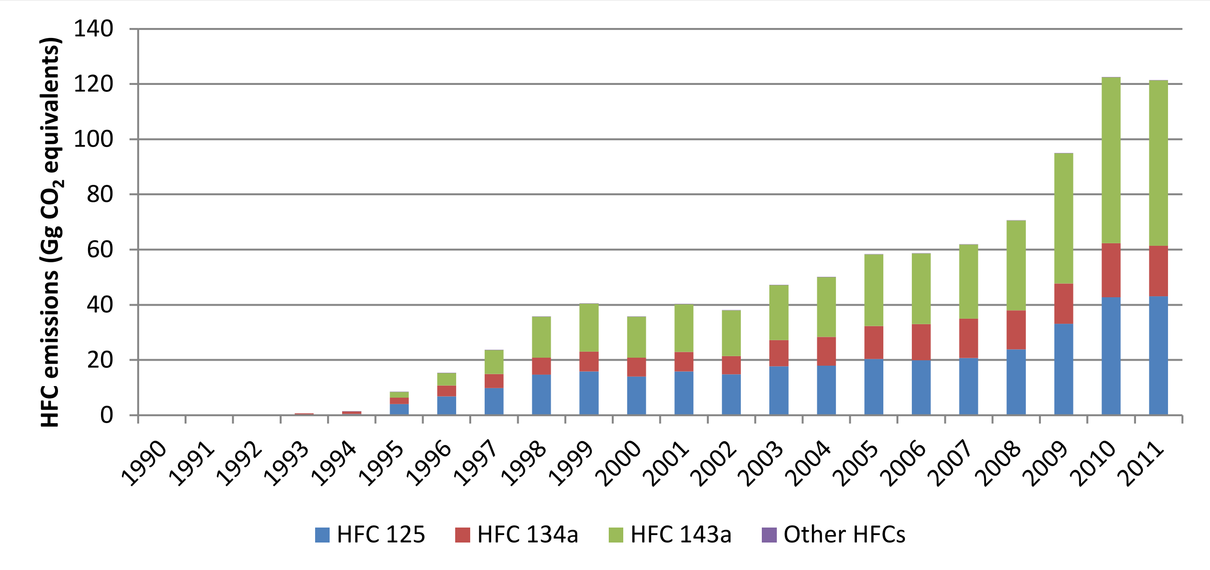

Figure 2.11. Actual emissions of HFCs 1990-2011, Gg CO_2-equivalents (HFC-23, HFC-32, HFC-152 and HFC-227 cannot be seen in figure due to proportionally low levels compared to three major HFCs).

2.2.6 *Sulphur Hexafluoride (SF_6)*

The sole source of SF_6 emissions in Iceland is leakage from electrical equipment. Total emissions in 2011 were 131 kg SF_6 which is tantamount to 3.1 Gg CO_2-equivalents. Emissions have been increasing by 172% since 1990. This increase reflects the expansion of the Icelandic electricity distribution system since 1990 which is accompanied by an increase in SF_6 used in high voltage gear. The emission peak in 2010 was caused by two unrelated accidents during which the SF_6 amounts contained in the gear affected by the accidents was emitted (Figure 2.12).

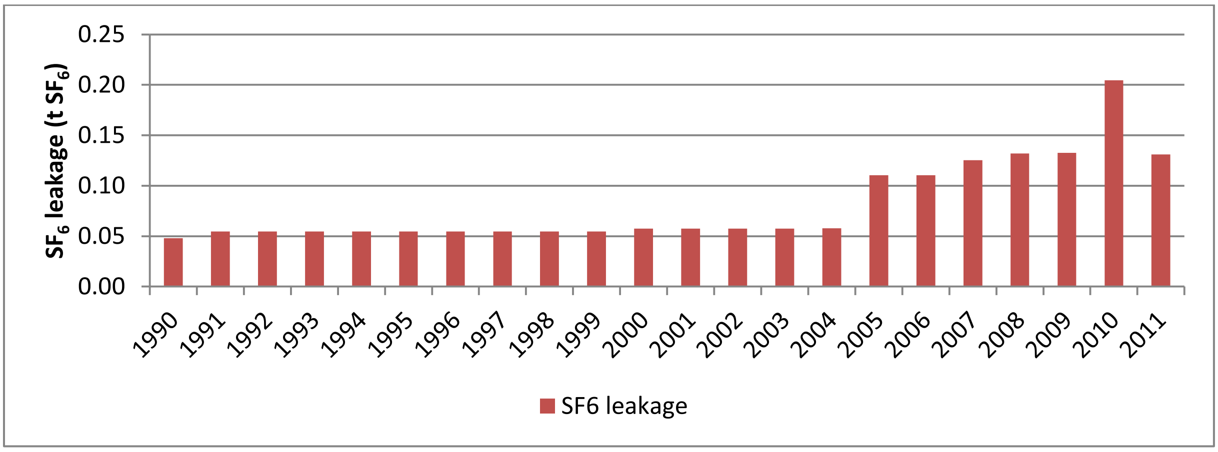

Figure 2.12. Emissions of SF_6 from 1990 to 2011 in tonnes SF_6.

2.3 Emission Trends by Source

Industrial processes are the largest contributor of greenhouse gas emissions in Iceland (without LULUCF), followed by Energy, Agriculture, Waste, and Solvent and other Product Use. The contribution of Industrial Processes to total net emissions (without LULUCF) increased from 25% in 1990 to 41% in 2011. The contribution of the Energy sector decreased from 51% in 1990 to 40% in 2011. Agriculture and the waste sector accounted for 15% and 4% of 2011 emissions, respectively (cf. Table 2.1 and Figure 2.13 to Figure 2.15).

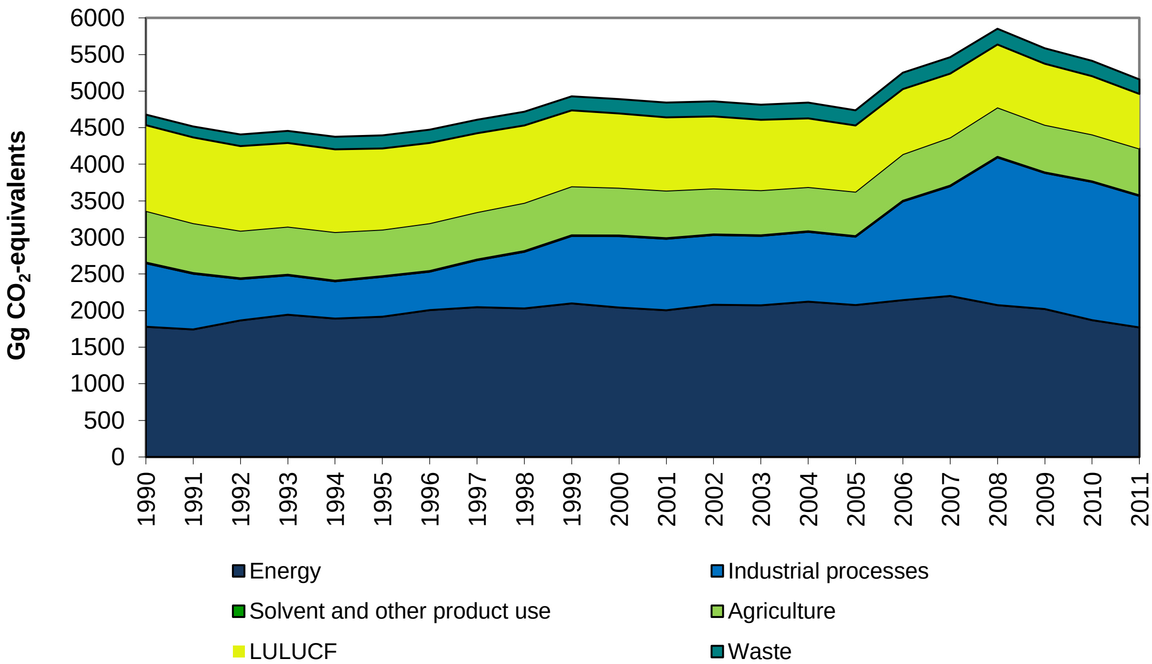

Figure 2.13. Emissions of GHG by sector from 1990 to 2011 in CO_2-equivalents.

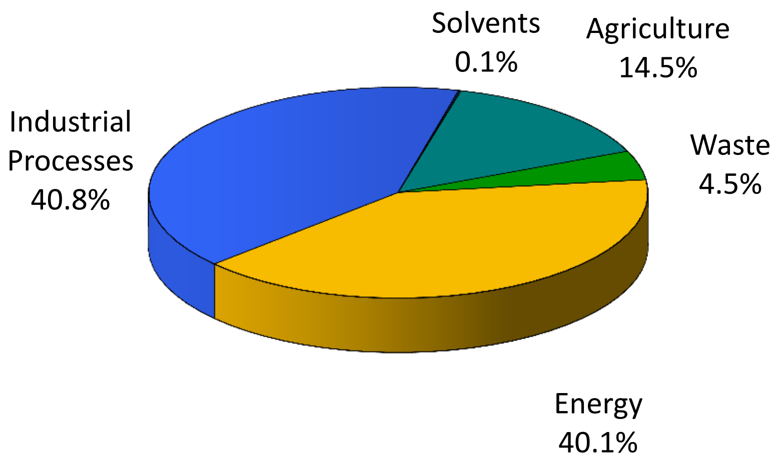

Figure 2.14. Emissions of greenhouse gases by UNFCCC sector in 2011.

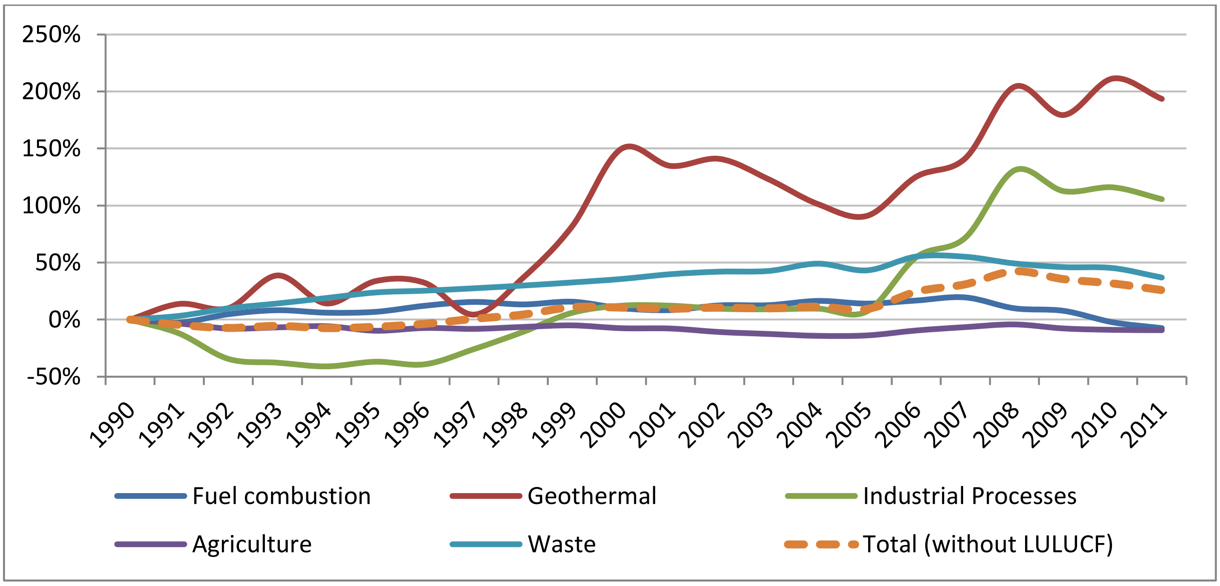

Figure 2.15. Percentage changes in emissions of total greenhouse gas emissions by UNFCCC source categories during the period 1990-2011, compared to 1990 levels.

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 and in 2011 the consumption per capita was about 737 GJ. However, the proportion of domestic renewable energy in the total energy budget is 85%, which is a much higher share than in most other countries. The cool climate and sparse population calls for high energy use for space heating and transport. Also, key export industries such as fisheries and metal production are energy-intensive. The metal industry used around 80% of the total electricity produced in Iceland in 2011. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (27% of the electricity) and on hydropower for electricity production (73% 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 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.

Fuel Combustion

The total emissions of greenhouse gases from fuel combustion in the Energy sector over the period 1990 to 2011 are listed in Table 2.8. Emissions from fuel combustion in the Energy sector accounted for 36% of the total greenhouse gas emissions in Iceland in 2011.

Figure 2.16 shows the distribution of emissions in 2011 by different source categories. The percentage change in the various source categories in the Energy sector between 1990 and 2011, compared with 1990, are illustrated in Figure 2.17.

Table 2.8. Total emissions of GHG from the fuel combustion in the Energy sector in 1990-2011, CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
Energy industries	14	19	7	9	8	9	7	7
Manufacturing industry and construction	377	378	450	447	369	264	213	193
Transport	621	628	674	849	973	946	900	864
- Road	529	561	633	800	891	892	844	824
- Other	92	67	41	49	82	54	56	40
Other sectors	705	808	756	651	536	629	556	524
- Fishing	662	780	728	633	523	603	540	505
- Residential/ commercial	43	28	29	18	14	26	16	18
Total	1,717	1,833	1,807	1,957	1,884	1,845	1,674	1,588

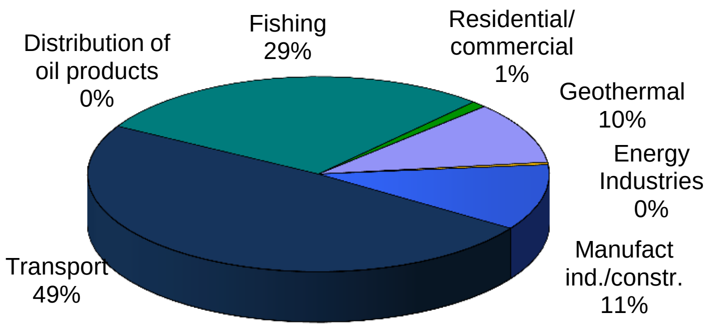

Figure 2.16. Greenhouse gas emissions in the Energy sector 2011, distributed by source categories.

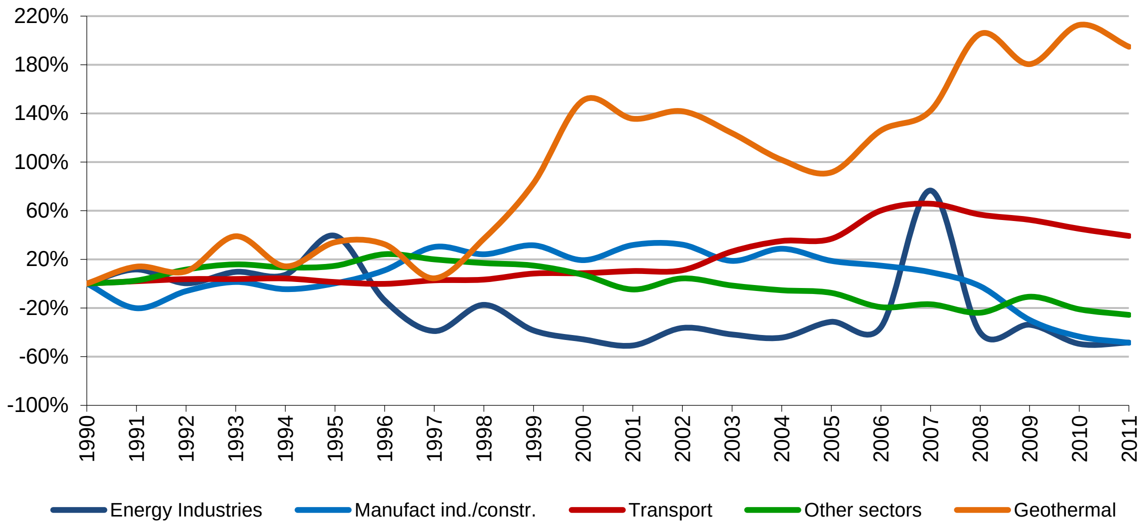

Figure 2.17. Percentage changes in emissions in various source categories in the Energy sector during the period 1990-2011, compared to 1990.

Table 2.8 and Figure 2.17 show that emissions from transport have increased (by 39%) as emissions from other sector (dominated by fishing) have decreased (by 26%). Emissions from energy industries are 49% below 1990 levels and emissions from manufacturing industries and construction are 49% below 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 very low. Since 1997 emissions have been around 40% lower in normal years than in 1990. Emissions from energy industries accounted for 0.4% of the sector's total and 0.2% of the total GHG emissions in Iceland in 2011. Electricity is produced with fuel combustion at 2 locations, which are located far from the distribution system (two islands, Flatey and Grimsey). Some electricity facilities have backup systems using 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 (snow avalanches in the west fjords and icing in the northern part of the country) 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 and industry depending on curtailable energy, leading to increased fuel combustion and emissions. This also has an effect on the implied emission factor (IEF) for energy industries, as waste and residual fuel oil have different emission factors. In years where more oil is used in the sector the IEF is considerably higher than in normal years.

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 rose until 2007, where the rise, particularly in the years prior to 2007, was related to the construction of Iceland's largest hydropower plant (Kárahnjúkar, building time from 2002 to 2007). The construction sector collapsed in fall 2008 due to the economic crises and the emissions from the sector decreased by 55% between 2007 and 2011. Further, since 2007 emissions from fuel combustion at the cement plant have decreased by 69% as a result of the collapse of the construction sector. 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.

Emissions from the Transport sector increased by 39% from 1990 to 2011. Emissions from road transport have increased by 56% since 1990, owing to an increase in the number of cars per capita, more mileage driven and until 2007 an increase in larger vehicles. Since 1990 the vehicle fleet in Iceland has increased by 143%. Also, the Icelandic population has grown by 25% from 1990 to 2011. Emissions from road vehicles peaked in 2007. Emissions decreased in 2008 and were 5% below the emissions in 2007 but increased by 0.1% between 2008 and 2009. It is likely that the economic crisis has led to fewer air flights abroad and therefore more travel within Iceland during summer vacation. This would explain why emissions from road transport have not decreased more during 2008 and 2009 despite significantly higher fuel prices, owing to the depreciation of the Icelandic króna during the year. In 2009, 2010 and 2011 fuel prices continued to rise. In recent years more fuel economic vehicles have been imported – a turn-over of the trend from the years 2002 to 2007 when larger vehicles were imported. This can be seen in less fuel consumption in 2010 than in 2009 despite the fact that driven mileage stayed almost the same. Numbers on driven mileage in 2011 are not yet available. Emissions from both domestic flights and navigation have declined since 1990 and this decrease in navigation and aviation has compensated for rising emissions in the transport sector to some extent.

The fisheries dominate the Other sector as heating in Iceland relies on renewable energy sources. 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 2011 emissions were 24% below the 1990 level and 6% below the 2010 level. Annual changes are inherent to the nature of fisheries.

Geothermal Energy

Emissions from geothermal energy utilization accounts for 4% of the total greenhouse gas emissions in Iceland in 2011. Iceland relies heavily on geothermal energy for space heating (over 90% of the homes) and electricity production (27% of the total electricity production). The emissions from geothermal power plants are considerably less than from fossil fuel power plants, or 19 times. Table 2.9 shows the emissions from geothermal energy from 1990 to 2011. Electricity production using geothermal power increased more than 16-fold during this period from 283 to 4,701 GWh. Emissions during the same time increased by 195%. Emissions from geothermal utilization are site and time-specific, and can vary greatly between areas and the wells within an area as well as by the time of extraction.

Table 2.9. Emissions from geothermal energy from 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
Geothermal energy	62	83	154	118	188	173	193	182

Distribution of oil products

Emissions from distribution of oil products are a minor source in Iceland. Emissions are around 0.3 to 0.5 Gg per year.

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. Emissions also occur as a result of the use of HFCs as substitutes for ozone depleting substances and SF_6 from electrical equipment. The Industrial Process sector accounts for 41% of the national greenhouse gas emissions as can be seen in Table 2.10 and Figure 2.18 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, especially after 2005 as the production capacity in the aluminium industry has increased. By 2011, emissions from the industrial processes sector were 107% above the 1990 level.

Table 2.10. Emissions from industrial processes 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
Mineral products	52	38	66	56	63	30	11	21
Chemical industry	49	43	19	-	-	-	-	-
Metal production	767	456	855	818	1883	1732	1752	1653
- **Ferroalloys**	208	243	375	375	347	348	369	375
- **Aluminium**	559	213	480	443	1536	1384	1383	1278
○ Aluminium CO_2	139	154	353	417	1187	1231	1238	1214
○ Aluminium PFC	420	59	127	26	349	153	146	63
Consumption of HFCs and SF_6	1	10	37	61	74	98	127	124
Total	**869**	**546**	**977**	**935**	**2020**	**1861**	**1890**	**1799**
Emissions fulfilling 14/CP.7*					1177	1201	1229	1209

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

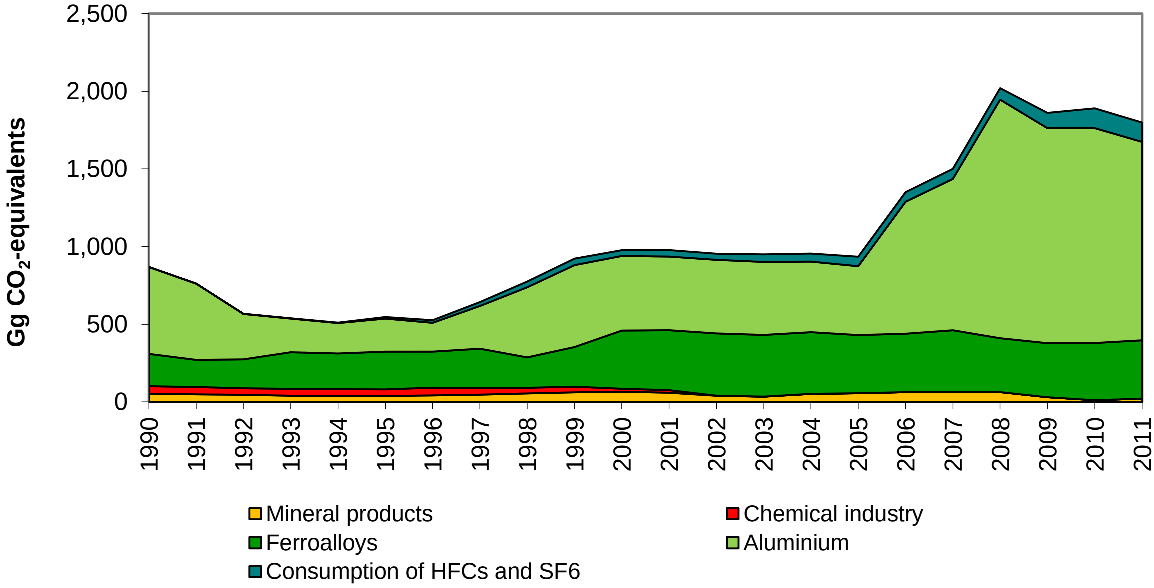

Figure 2.18. Total greenhouse gas emissions in the Industrial Process sector during the period from 1990-2011 in Gg CO_2-equivlalents.

The most significant category within the industrial processes sector is metal production, which accounted for 88% of the sector's emissions in 1990 and 92% in 2011. Aluminium production is the main source within the metal production category, accounting for 71% 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 per tonne of aluminium at the Century Aluminium plant went down from 2007 to 2011 through improved process technology, reaching 0.12 tonnes CO_2-equivalents per tonne aluminium in 2011. 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. PFC emission declined in 2009 and 2010 through improved process technology until December 2010 at Alcoa Fjarðaál, when a rectifier was damaged in fire. This led to increased PFC emissions leading to higher emissions at the plant in 2010 than in 2009. In 2011 PFC emissions per tonne of aluminium at the Alcoa Fjarðaál went down to 0.07 tonnes CO_2-equivalents per tonne aluminium.

Production of ferroalloys is another major source of emissions, accounting for 21% of industrial processes emissions in 2011. 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 ferrosilican plant, resulting in exceptionally low emissions that year. In 1999, however, the plant was expanded (addition of the third furnace) and emissions have therefore increased considerably, or by 80% since 1990. Emissions in 2011 were 2% higher than in 2010.

Production of minerals accounted for 1.1% of the emissions in 2011. 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 raw material. 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. Since 2007 emissions from the plant have decreased by 69%.

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 a silicon production facility in 2004.

Imports of HFCs started in 1993 and have increased steadily since then. HFCs are used as substitutes for ozone depleting substances that are being phased out in accordance with the Montreal Protocol. Refrigeration and air conditioning are the main uses of HFCs in Iceland and the fishing industry plays a preeminent role. HFCs stored in refrigeration units constitute banks of refrigerants which emit HFCs during use due to leakage. The process of retrofitting older refrigeration systems and replacing ODS as refrigerants is still on-going which means that the size of the refrigerant bank is still increasing, causing an accelerated increase of emissions since 2008. The amount of HFCs emitted by mobile air conditioning units in vehicles has also been increasing steadily (Table 2.11).

The sole source of SF_6 emissions is leakage from electrical equipment. Emissions have been increasing since 1990 due to the expansion of the Icelandic electricity distribution (Table

2.11). The peak in 2010 was caused by two unrelated accidents during which the SF_6 contained in the equipment leaked into the atmosphere.

Table 2.11. HFC and SF_6 emissions from consumption of HFC and SF_6 in Gg CO_2 equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
HFCs (refrigeration)	0.0	8.5	35.8	57.7	69.9	94.3	121.8	120.5
HFCs (metered dose inhalers)	0.0	0.0	0.0	0.7	0.7	0.7	0.8	0.8
SF6 (electricalequipment)	1.1	1.3	1.4	2.6	3.2	3.2	4.9	3.1

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. Also included in this sector are emissions of N_2O from product uses. N_2O is used mainly for medical purposes. To a smaller extent it is also used in car racing and fire extinguishing.

Total NMVOC emissions from solvent and other product use amounted to 2.8 Gg CO_2-equivalents in 2011 (less than 0.1% of total GHG emissions), which was 8% below the 1990 level and 3% above the 2010 level. This development was mainly due to a decrease in paint application. Emissions from N_2O use decreased by 42% between 1990 and 2011 due to decreasing imports for medical purposes (anaesthesia).

2.3.4 Agriculture

Emissions from agriculture are closely coupled with livestock population sizes, especially cattle and sheep. Since emission factors were assumed to be stable during the last two decades (with the exception of gross energy intake of dairy cows, which increased as reflected in an increase in milk production), changes in activity data translated into proportional emission changes. The only other factor that had considerable impact on emission estimates was the amount of nitrogen in fertilizer applied annually to agricultural soils. A 17% decrease in livestock population size of sheep between 1990 and 2005 – partly counteracted by increases of livestock population sizes of horses, swine, and poultry - led to emission decreases from all subcategories and resulted in a 13% decrease of total agriculture emissions during the same period (Table 2.12 and Figure 2.20). Since 2005 emissions from agriculture have increased by 5% due to an increase in livestock population size but still remain 9% below 1990 levels.

This general trend is modified by the amount of synthetic nitrogen applied annually to agricultural soils. The amount was highest in 2008, when it amounted to more than 15,300 tonnes, but has decreased to less than 10,400 tonnes in 2011. This development was due to the economic crisis in Iceland which was accompanied by a weakening of the Icelandic króna thus increasing the price of imported fertilizer.

The largest sources of agricultural greenhouse gas emissions in 2011 were nitrous oxide emissions from agricultural soils: direct soil N_2O emissions, indirect soils N_2O emissions, and N_2O emissions from pasture and range manure accounted for 54% of total agriculture emissions (Figure 2.19). The remaining 46% were made up of methane emissions from enteric fermentation and methane and nitrous oxide emissions from manure management (i.e. before the manure is applied to soils).

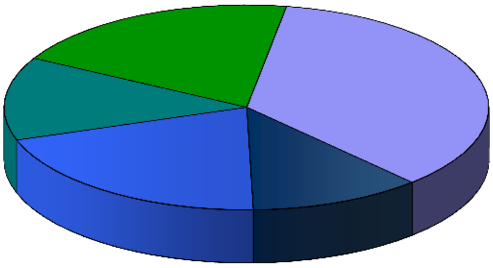

Figure 2.19. Greenhouse gas emissions in the agriculture sector 2011, distributed by source categories.

Table 2.12. Total greenhouse gas emissions from agriculture in 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
Manure management	83	69	72	69	71	73	73	74
Direct soil emissions	149	135	144	125	156	138	131	130
Pasture and range manure	90	82	82	81	82	83	84	84
Indirect soil emissions	141	127	134	119	144	132	127	126
Enteric fermentation	244	224	221	214	223	226	228	227
Total emissions	706	637	653	608	676	651	643	641

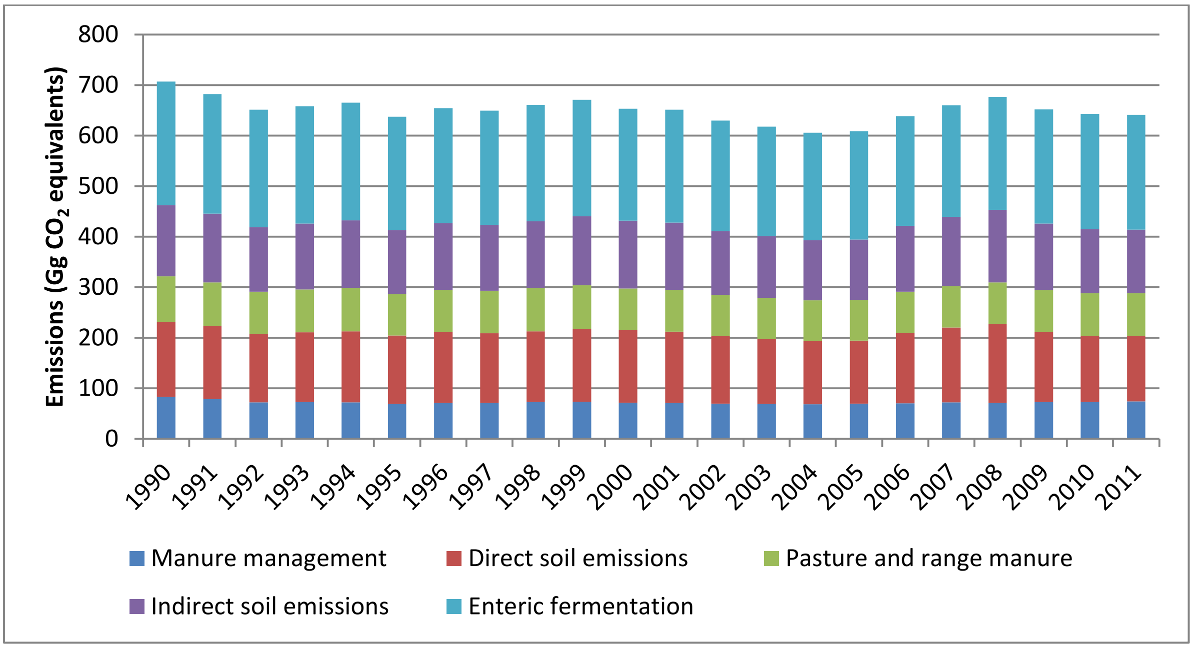

Figure 2.20. Total greenhouse gas emissions from agriculture 1990-2011 in Gg CO2-equivalents.

2.3.5 *Land Use, Land-Use Change and Forestry (LULUCF)*

Net emissions from the LULUCF sector in Iceland are high; the sector had the third highest net emissions in 2011 but the second most in 1990. A large part (62%) of the absolute value of emissions from the sector in 2011 was from cropland and grassland on drained organic soil. 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.

Net emissions (emissions – removals) in the sector have decreased over the time period, as can be seen in Table 2.13. This is explained by increased removals through afforestation and revegetation as well as a decrease in emissions from land converted to cropland. Increased removals in afforestation and revegetation are explained by the increased activity in those categories and changes in forest growth with stand age.

Table 2.13. Emissions from the LULUCF sector from 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
Forest land - Natural birch forest	-16	-22	-28	-34	-37	-38	-39	-41
Forest land - Afforestation	-28	-47	-79	-124	-139	-152	-175	-209
Cropland remaining cropland	764	872	963	1,018	1,026	1,022	1,015	1,008
Land converted to cropland	434	297	177	95	69	65	64	64
Grassland remaining grassland	167	219	242	273	275	275	274	274
Other land converted to grassland, revegetation	-349	-378	-424	-474	-502	-509	-516	-523
Other conversion to grassland	127	84	75	60	72	75	77	76
Land converted to wetland (reservoirs)	3	14	17	17	18	18	18	18
Forest land converted to settlements	NO	NO	NO	0	0	0	0	0
Grassland non CO2-emissions	69	69	72	74	77	77	78	78
Net LULUCF	**1,171**	**1,109**	**1,015**	**905**	**859**	**835**	**796**	**746**

Analyses of trends in emissions of the LULUCF sector must be interpreted with care as some potential sinks and sources are not included. Uncertainty estimates for reported emissions are considerable 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 174 Gg (Net – Net accounting) in 2011. Removals from activities under Articles 3.3 (Afforestation and Reforestation) amounted to 162 Gg in 2011. Afforestation falling under Convention reporting amounted to 209 Gg. The difference (46 Gg) is explained by a C-stock increase in older forests (72 Gg) minus the removals (26 Gg) reported under Article 3.3 that originate from the expansion of natural birch forests, not included with “Forest land –afforestation” in Table 2.13 (rounded values).

2.3.6 Waste

Emissions from the Waste sector accounted for less than 5% of total GHG emissions in 2011. About 89% of these emissions were methane emissions from solid waste disposal on land. 6% were CH_4 and N_2O emissions from wastewater treatment and 4% were CO_2, CH_4 and N_2O emissions from waste incineration. The remaining 1% originated from biological treatment of waste, i.e. composting. Emissions from the waste sector increased steadily from 1990 to 2007 due to an increase in emissions from solid waste disposal on land (SWD) (Table 2.14 and Figure 2.21). This increase was caused by the accumulation of degradable organic carbon in recently established managed, anaerobic solid waste disposal sites which are characterised by higher methane production potential than the unmanaged SWDS they succeeded. The decrease in emissions from the waste sector since 2007 is also caused by a decrease in SWD emissions which is due to a rapidly decreasing share of waste landfilled since 2005. The total increase of SWD emissions between 1990 and 2011 amounted to 47%.

Table 2.14. Total emissions from the Waste sector from 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
Solid waste disposal	119	158	180	189	196	190	189	176
Wastewater	8	9	9	12	11	11	11	12
Incineration	18	12	7	5	7	8	7	9
Composting		0.4	0.4	0.9	1.9	2.3	2.7	2.5
Total emissions	**145**	**179**	**196**	**207**	**216**	**211**	**210**	**198**

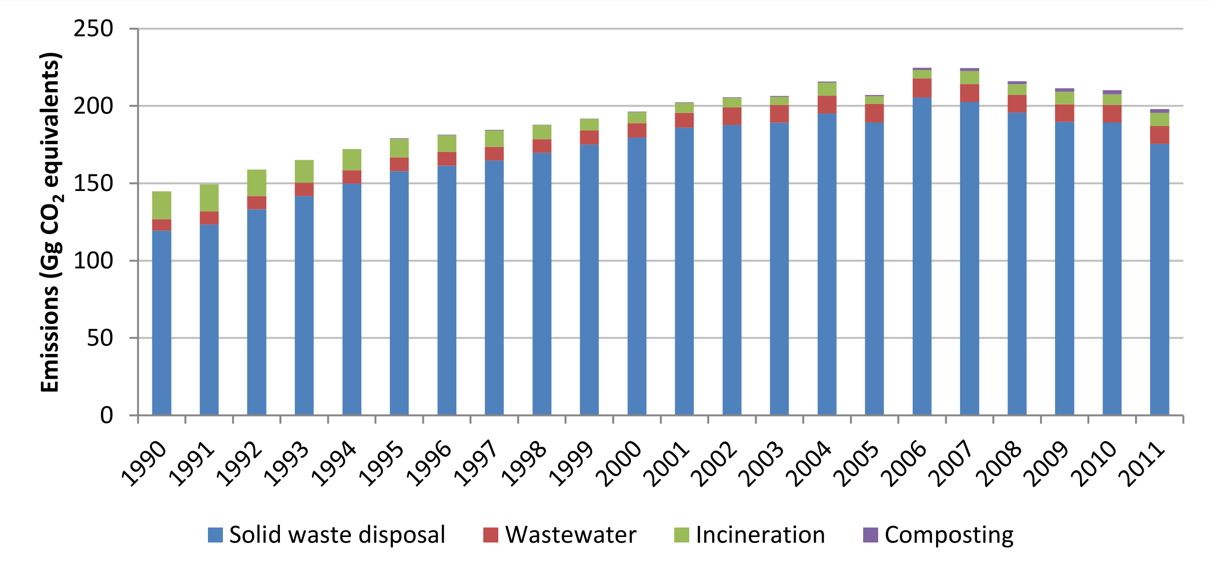

Figure 2.21. Aggregated GHG emissions of the Waste sector 1990-2011 in Gg CO_2-equivalents.

Total wastewater handling emissions increased by 51% since 1990 due to increasing N_2O and CH_4 emissions. The increase in N_2O emission estimates is proportional to an increase in population. The increase in methane emissions is mainly due to an increase in the share of wastewater treated in septic systems. All other wastewater discharge pathways were assumed to emit no methane since the wastewater is either treated aerobically or discharged into fast running rivers or straight into the sea.

Emissions from waste incineration decreased by 52% between 1990 and 2011 due to a decrease in the amount of waste incinerated and a change in waste incineration technology. During the early 1990s waste was either burned in open pits or in waste incinerators at low or varying temperatures. Since the mid-1990s increasing amounts of waste are incinerated in proper waste incinerators that control combustion temperatures which lead to lower emissions of CO_2, CH_4 and N_2O per waste amount incinerated (Figure 2.22). The CO_2 emission factor for waste incineration is slightly higher than for open burning of waste (oxidisation factor of 1 vs. 0.58), but the CH_4 emission factor for open burning of waste is, however, 27 times higher and the N_2O emission factor 2.5 times higher than the one for waste incineration.

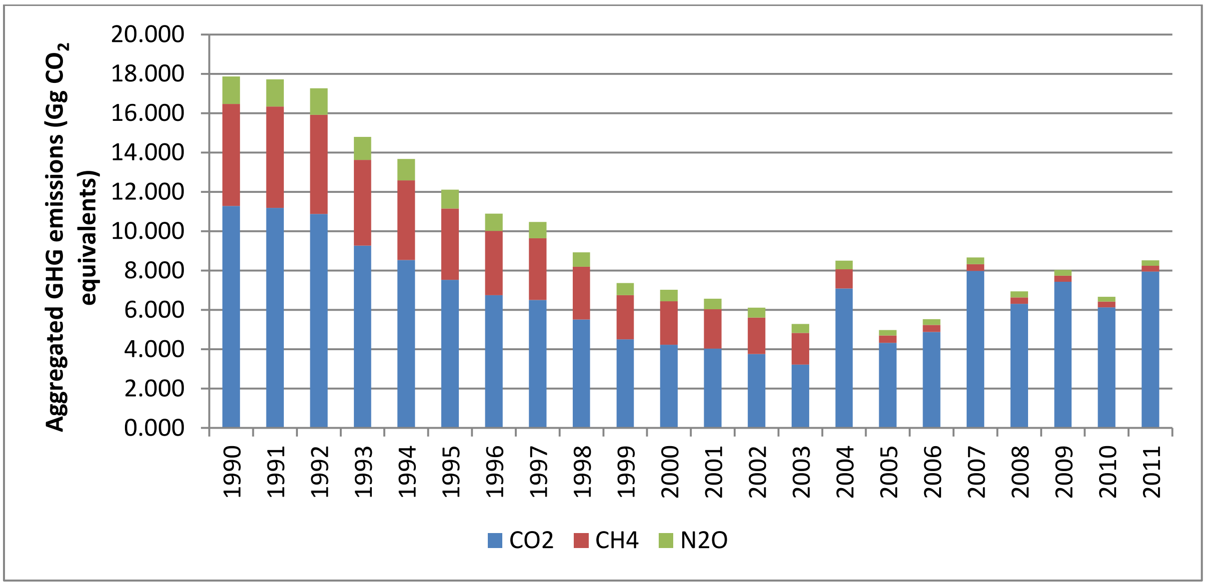

Figure 2.22. Emissions from waste incineration.

Emissions from composting have been steadily increasing since composting started in Iceland the year 1995 and accounted for roughly 1% of total waste sector emissions in 2011. Between 2010 and 2011 composting emissions decreased by 6% due to decreasing amounts of waste composted.

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 2.15.

In 2011, greenhouse gas emissions from ships and aircrafts in international traffic bunkered in Iceland amounted to a total of 626 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 76% from 1990 to 2011; with a 11% increase between 2010 and 2011.

Looking at these two categories separately, it can be seen that greenhouse gas emissions from international marine bunkers increased by 101% from 1990 to 2011, while emissions from aircrafts increased by 92% during the same period. Between 2010 and 2011 emissions from marine bunkers increased by 9% while emissions from aviation bunkers increased by 12%. Emissions from international bunkers are rising again after decline since 2007. Foreign commercial fishing vessels dominate the fuel consumption from marine bunkers.

Table 2.15. Greenhouse gas emissions from international aviation and marine bunkers 1990-2011 in Gg CO_2-equivalents.

	1990	1995	2000	2005	2008	2009	2010	2011
Aviation	222	238	411	425	432	337	381	426
Marine	100	146	221	112	231	167	184	201
Total	**322**	**384**	**632**	**538**	**663**	**503**	**565**	**626**

2.4 Emission Trends for Indirect Greenhouse Gases and SO_2

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

2.4.1 Nitrogen Oxides (NOx)

The main sources of nitrogen oxides in Iceland are commercial fishing, transport, and the manufacturing industry and construction, as can be seen in Figure 2.23. The NO_x emissions from commercial fishing rose from 1990 to 1996 when a substantial portion of the commercial fishing fleet was operating in distant fishing grounds. From 1996 emissions decreased, reaching the 1990 levels in 2001. Emissions rose again in 2002 but have declined since with exception of 2009 due to less fuel consumption. Emissions in 2011 were 24% 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 27%) after the use of catalytic converters in all new vehicles became obligatory in 1995, despite the fact that fuel consumption has increased by 40%. The rise in emissions from the manufacturing industries and construction until 2007 are dominated by increased activity in the construction sector during the period. In 2008 the construction sector collapsed leading to much lower emissions from the sector. In 2011 emissions from manufacturing industry and construction were 37% lower than in 1990. This is due to the collapse of the construction sector (including lower emissions from the cement plant) and to less fuel consumption at fishmeal plants where fuel has been replaced with electricity and production has decreased. Total NO_x emissions, like the emissions from fishing, increased until 1996 and decreased thereafter until 2001. Emission rose again between 2001 and 2004 and then decreased again. Total NO_x emissions in 2011 were 23% below the 1990 level.

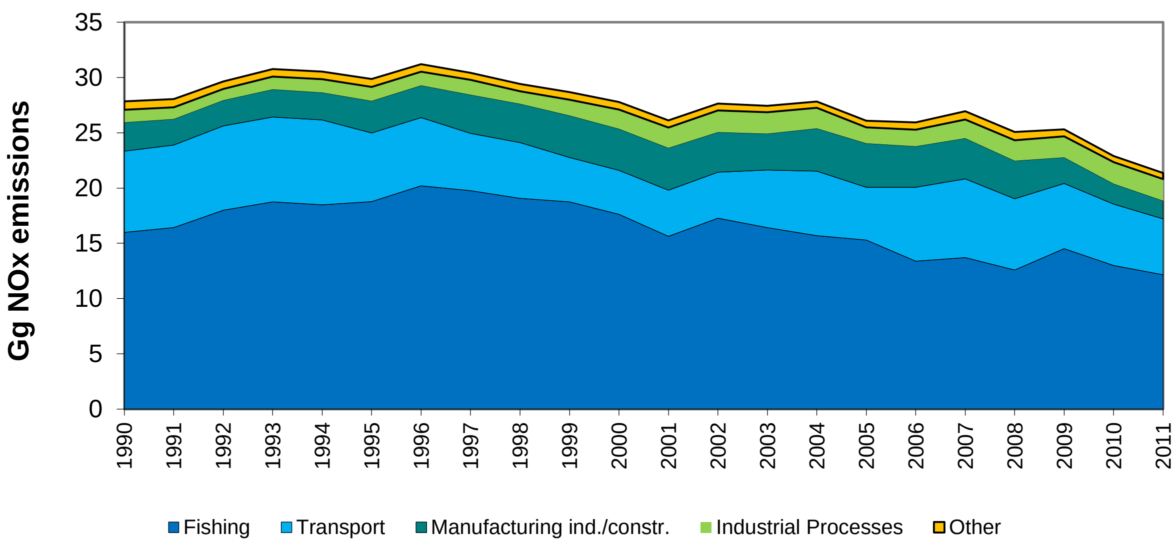

Figure 2.23. Emissions of NO_x by sector 1990-2011 in Gg.

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 been around 1 Gg and show a downward trend in recent years. Other emissions include emissions from industrial processes, where food and drink production is the most prominent contributor. The total emissions showed a downward trend from 1994 to 2011. The emissions in 2011 were 56% below the 1990 level.

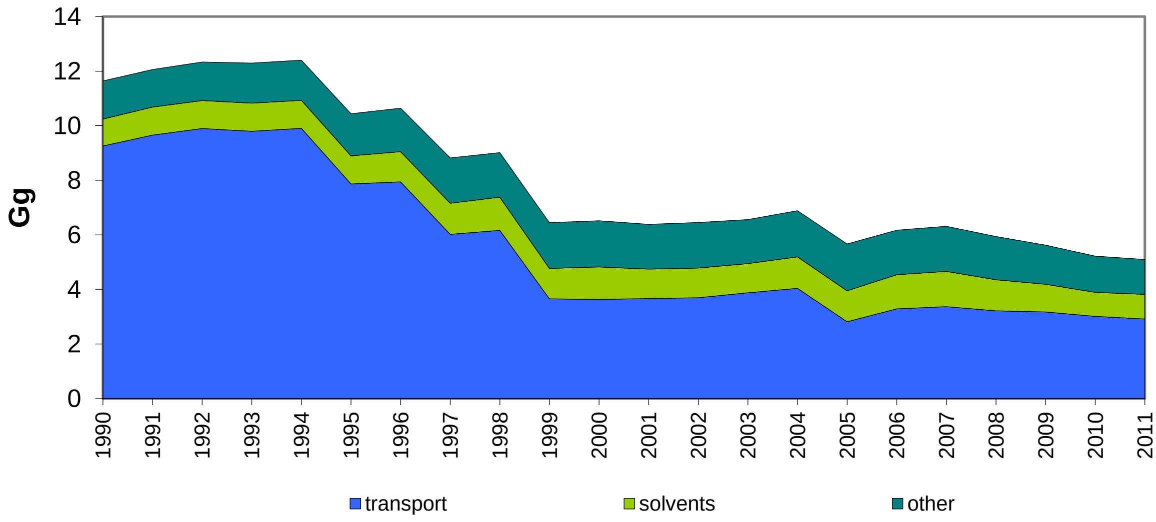

Figure 2.24. Emissions of NMVOC by sector 1990-2011 in Gg.

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 2011 were 60% below the 1990 level.

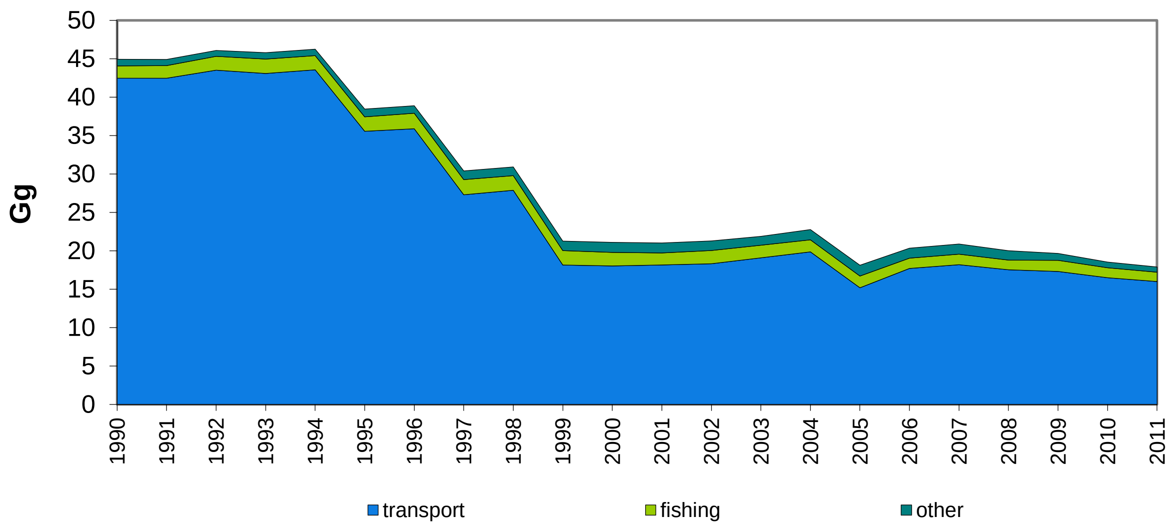

Figure 2.25*. Emissions of CO by sector 1990-2011 in Gg.*

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 384% since 1990 due to increased activity in this field, as electricity production at geothermal power plants has increased more than 16-fold since 1990. Other significant sources of sulphur dioxide in Iceland are industrial processes, 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, 88,839 tonnes of aluminium were produced at one plant and 62,792 tonnes of ferroalloys at one plant. In 2011 806,319 tonnes of aluminium were produced at three plants and 105,193 tonnes of ferroalloys were produced at one plant. This led to increased emissions of sulphur dioxide (306% increase from 1990 levels). The fishmeal industry is the main contributor to sulphur dioxide emissions from fuel combustion in the sector Manufacturing Industries and Construction. Emissions from the fishmeal industry increased from 1990 to 1997 but have declined since as fuel has been replaced with electricity and production has decreased; the emissions were 68% below the 1990 level in 2011.

Sulphur emissions from the fishing fleet depend upon the use of residual fuel oil. When fuel prices rise, the use of residual fuel oil rises and the use of gas oil drops. This leads to higher sulphur emissions as the sulphur content of residual fuel oil is significantly higher than in gas oil. The rising fuel prices since 2008 have led to higher sulphur emissions from the commercial fishing fleet in recent years. Emissions from the fishing fleet in 2011 were 7% above the 1990 level although fuel consumption was 24% less.

In 2011 total sulphur emissions in Iceland, calculated as SO_2, were in 283% above the 1990 level, but 112% when excluding emissions from geothermal power plants.

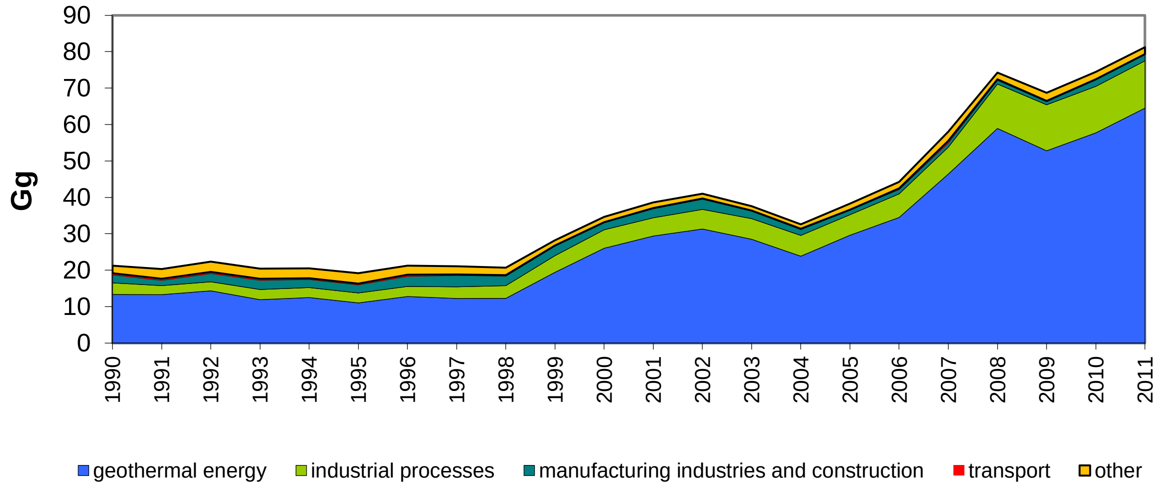

Figure 2.26. Emissions of S (sulphur) by sector 1990-2011 in Gg SO_2-equivalents.

In 2010 the volcano Eyjafjallajökull started eruption. The eruption lasted from 14th of April until 23rd of May. During that time 127 Gg of SO_2 were emitted or 71% more than total man made emissions in 2010. In 2011 the volcano Grímsvötn started erupting. The eruption lasted from 21st until 28th of May. During that time around 1000 Gg of SO_2 were emitted or 12 times more than total man made emissions in 2011. These emissions are given here for information purposes and are not included in the inventory.

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 per capita consumption in 2011 was about 737 GJ. However, the proportion of domestic renewable energy in the total energy budget is about 85%, which is a much higher share than in most other countries. The cool climate and sparse population calls for high energy use for space heating and transport. Also, key export industries such as fisheries and metal production are energy-intensive. The metal production industry used around 80% of the total electricity produced in Iceland in 2011. Iceland relies heavily on its geothermal energy sources for space heating (over 90% of all homes) and electricity production (27% of the electricity) and on hydropower for electricity production (73% of the electricity).

The Energy sector accounts for 40% (fuel combustion 36%, geothermal energy 4%, fugitive emissions from fuels 0%) of the GHG emissions in Iceland. Energy related emissions decreased by 0.5% from 1990 to 2011. Emissions from fuel combustion decreased by 7.5% from 1990 to 2011 while emissions from geothermal energy increased by 194.7%. From 2010 to 2011 the emissions from fuel combustion decreased by 5.3%, while emissions from geothermal energy decreased by 5.7%. Total emissions related to energy decreased by 5.3% from 2010 to 2011. Fisheries and road traffic are the sector's largest single contributors. Combustion in manufacturing industries and construction is also an important source. Recalculations have been made in the Energy sector since last submission as one waste incineration facility that had been allocated to the Waste sector is now allocated to the Energy sector. Activity data for kerosene was corrected for the year 2010 in the Residential sector. Emissions of CO_2, CH_4 and NMVOC from distribution of oil products have been estimated for the first time.

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 division of fuel sales by sector does not reflect the IPCC sectors perfectly so EA has made adjustments to the data where needed to better reflect the IPCC categories. Further explanation of this adjustment is given in Annex III. This applies for the sectors 1A1a Energy industries, 1A2 Manufacturing industry (stationary combustion) and 1A4 Residential.

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 2011 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:

- Manufacturing Industries and Construction – CO_2 (1A2)
  » This is a key source in level (1990, 2011) and trend
- Road Transport – CO_2 (1A3b)
  » This is a key source in level (1990, 2011) and trend
- Road Transport – N_2O (1A3b)
  » This is a key source in trend
- Non-Road Transport – CO_2 (1A3a/d)
  » This is a key source in level (1990) and trend
- Fishing – CO_2 (1A4c)
  » This is a key source in level (1990, 2011) and trend
- Geothermal Energy – CO_2 (1B2d)
  » This is a key source in level (1990, 2011) and trend

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**	**NO_x**	**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	E	E	NA	NA	NA	NA	NA	NA	E	NA
- 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 yet been developed for the Energy sector.

3.2 Energy Industries (1A1)

Energy Industries include emissions from electricity and heat production. Iceland has extensively utilised renewable energy sources for electricity and heat production, thus emissions from this sector are low. Emissions from Energy Industries accounted for 0.4% of the sectors total and 0.2% of the total GHG emissions in Iceland in 2011.

Activity data for the energy industries are based on data provided by the NEA and adjusted by EA, see Annex III. 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 3.4 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 emission factors (EFs) from Tables 1.7 to 1.11 in the Reference Manual were used where EFs are missing. The CO_2 emission factor for waste incineration was calculated using Tier 2 methodology and default values from the 2006 GL. The IEF for energy industries is affected by the different consumption of waste and fossil fuels, as waste, gasoil and residual fuel oil have different EF. In years where more oil is used the IEF is considerably higher than in normal years.

3.2.1 Electricity Production

Electricity was produced from hydropower, geothermal energy and fuel combustion in 2011 (Table 3.2) with hydropower as the main source of electricity (Orkustofnun, 2012). Electricity was produced with fuel combustion at a two locations that are located far from the distribution system (two islands, Grimsey and Flatey). Some public electricity facilities have emergency backup fuel combustion power plants which they can use when problems occur in the distribution system. Those plants are however very seldom used, apart from testing and during maintenance.

Table 3.2. Electricity production in Iceland (GWh).

	1990	1995	2000	2005	2008	2009	2010	2011
Hydropower	4,159	4,678	6,352	7,014	12,427	12,279	12,592	12,507
Geothermal	283	288	1,323	1,658	4,037	4,553	4,465	4,701
Fuel combustion	5.6	8.4	4.4	7.8	2.7	2.9	1.7	2.1
Total	**4,447**	**4,977**	**7,679**	**8,680**	**16,467**	**16,835**	**17,059**	**17,210**

Activity data

Activity data for electricity production is calculated from the information on electricity production, from the energy content of the gasoil (43.33 TJ/kt) assuming 34% efficiency. Activity data for fuel combustion and the resulting emissions are given in Table 3.3 .

Table 3.3. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from electricity production.

	1990	1995	2000	2005	2008	2009	2010	2011
Gas/Diesel oil (kt)	1.4	2.1	1.1	1.9	0.7	0.7	0.4	0.5
Emissions (Gg)	**4.4**	**6.7**	**3.6**	**6.3**	**2.2**	**2.3**	**1.4**	**1.7**

Emission Factors

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 3.4 along with sulphur content of the fuels.

Table 3.4. 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 [%]
Gas/Diesel oil	43.33	20.20	0.99	3.18	0.2

The resulting emissions of GHG from electricity produced from fuels in GHG per kWh amount to 800 g of CO_2 per kWh.

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 18 Gg of CO_2-equivalents and emissions from geothermal power plants to 182 Gg of CO_2-equivalents, in 2011. The resulting emissions of GHG per kWh amount to 1.4 g CO_2-equivalents/kWh for hydropower plants and to 39 g CO_2-equivalents/kWh for geothermal energy. The weighted average GHG emissions from electricity production in Iceland in 2011 were thus 11.7 g/kWh.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from electricity production with fuels is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II.

3.2.2 Heat Production

Geothermal energy was the main source of heat production in 2011. 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.

Activity Data

Activity data for heat production with fuel combustion and waste incineration and the resulting emissions are given in Table 3.5. No fuel consumption for heat production was reported by the NEA for 2010 and 2011.

Table 3.5. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equvalents) from heat production.

	1990	1995	2000	2005	2007	2008	2009	2010	2011
Residual fuel oil	3.0	3.1	0.1	0.2	4.5	0.1	0.1	-	-
Gas/Diesel oil	-	-	-	-	-	-	-	-	-
Solid waste	-	4.7	6.1	5.4	12.0	10.3	9.5	8.2	7.5
Emissions (GHG)	**9.2**	**12.3**	**3.8**	**3.1**	**21.3**	**6.0**	**6.7**	**5.5**	**5.3**

Emission Factors

Fuel combustion used for CO_2 emission factors (EF) reflects 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. The CO_2 emission factor for waste incineration was calculated using Tier 2 methodology and default values from the 2006 GL. Therefore the waste amounts incinerated are dissected into eleven categories. The dry matter content, total, and fossil carbon fractions are calculated separately for each waste category and then added up. In the years that have higher fractions of fossil carbon containing waste categories such as plastics the EF is higher than in other years since the EF is related to the total amount of waste incinerated. CO_2 EF varied between 0.44 and 0.69 t CO_2 per tonne waste (cf. chapter 8.4.3).

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 [%]
Residual fuel oil	40.19	21.10	0.99	3.08	1.8
Gas/Diesel oil	43.33	20.20	0.99	3.18	0.2
Solid waste	10.70	14.53	1	0.57[1]	0.17

[1] mean value. Annual values vary between 0.44 and 0.69 t CO_2/t waste depending on fossil carbon content of waste incinerated.

Recalculations

Since last submission two changes have been made regarding waste incineration with energy recovery. New waste composition data was incorporated which led to slightly higher fossil carbon content and slightly lower dry matter fraction of waste incinerated. The former change increased emissions by increasing CO_2 emissions whereas the latter change decreased emissions by reducing N_2O emissions whose EF is related to dry weight. For the years 1993-2004 this EF change meant a 5.3% emission increase of aggregated emissions from waste incineration. For the period 2006-2010 this EF change is overshadowed by the second change made regarding waste allocation: the reallocation of one incineration plant from waste incineration without energy recovery to the Energy sector. Along with the EF change described above thus increased waste amounts increased aggregated emissions by 47-72% between 2006 and 2010.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from heat production with fuels is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II.

3.3 Manufacturing Industries and Construction (1A2)

Emissions from the Manufacturing Industries and Construction account for 10.9% of the Energy sector's total and 4.4% of total GHG emissions in Iceland in 2011. Mobile Combustion in the Construction sector accounts for 51.2% of the total emissions from Manufacturing Industries and the Construction sector.

3.3.1 Manufacturing Industries, Stationary Combustion

Activity Data

Information about the total amount of fuel used by the manufacturing industries was obtained from the National Energy Authority and adjusted by EA (see Annex III). The sales statistics for the manufacturing industry (as adjusted by EA) are given for the sector as a total. They do not specify the fuel consumption by the different industrial sources. This division is made by EA on basis of the reported fuel use by all major industrial plants falling under law no. 65/2007 (metal production, cement) and from green accounts submitted by the industry in accordance with regulation 851/2002 for industry not falling under law no. 65/2007. There is thus a given total, which the usage in the different sectors must sum up to. All major industries, falling under law no. 65/2007 (metal and cement industries) report their fuel use to the EA along with other relevant information for industrial processes. Fuel consumption in the fishmeal industry from 1990 to 2002 was estimated from production statistics, but the numbers for 2003 to 2011 are based on data provided by the industry (application for free allowances under the EU ETS for the years 2005 to 2010, information from the Icelandic Association of Fishmeal Manufacturers for 2003, 2004 and 2011). The difference between the given total for the sector and the sum of the fuel use of the reporting industrial facilities are categorized as 1A2f other non-specified industry. Emissions are calculated by multiplying energy use with a pollutant specific emission factor (Table 3.7 and Table 3.8). Emissions from fuel use in the ferroalloys production is reported under 1A2a.

Table 3.7. Fuel use (kt) and emissions (GHG total in Gg CO_2-equivalents) from stationary combustion in the manufacturing industry.

	1990	1995	2000	2005	2008	2009	2010	2011
Gas/Diesel oil	5.1	1.1	10.3	22.2	8.6	9.8	9.4	4.9
Residual fuel oil	55.9	56.2	46.2	25.0	20.5	17.6	16.5	17.3
LPG	0.5	0.4	0.9	0.9	1.9	1.2	1.0	1.0
Electrodes (residue)	0.8	0.3	1.5	-	0.5	0.4	0.4	-
Steam Coal	18.6	8.6	13.3	9.9	21.5	10.2	3.6	7.8
Petroleum coke	-	-	-	8.1	-	-	-	-
Waste oil	-	5.0	6.0	1.8	2.2	0.9	1.4	1.2
Total Emissions	**241**	**210**	**228**	**205**	**157**	**118**	**97**	**94**

Emission Factors

The CO_2 emission factors (EF) used reflect the average carbon content of fossil fuels. They are, with the exception of NCV for steam coal, which was obtained from the cement 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 3.8 along with sulphur content of the fuels.

Table 3.8. Emission factors for CO_2 from fuel combustion and S-content of fuel (IE: Included Elsewhere).

	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. Further waste oil has mainly been used 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.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from manufacturing industries and constructions is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and for N_2O

emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II.

3.3.2 Manufacturing Industries, Mobile Combustion

Activity Data

Activity data for mobile combustion in the construction sector is provided by the NEA. Oil, which is reported to fall under vehicle usage, is in some instances actually used for machinery and vice versa as machinery sometimes tanks its fuel at a tank station, (thereby reported as road transport), as well as it happens that fuel sold to contractors, for use on machinery, is used for road transport (but reported under construction). This is, however, very minimal and the deviations is believed to level each other out. Emissions are calculated by multiplying energy use with a pollutant specific emission factor. Activity data for fuel combustion and the resulting emissions are given in Table 3.9.

Table 3.9. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from mobile combustion in the construction industry.

	1990	1995	2000	2005	2008	2009	2010	2011
Gas/Diesel oil	38	47	62	68	59	41	32	28
Emissions	**136**	**167**	**222**	**243**	**212**	**146**	**115**	**99**

Emission Factors

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, CH_4 and N_2O are presented in Table 3.10.

Table 3.10. Emission factors for CO_2, CH_4 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 manufacturing industries and constructions is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), the uncertainty of CH_4 emissions is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II.

3.4 Transport (1A3)

Emissions from Transport accounted for 48.8% of the Energy sector’s total and 19.6% of the total GHG emissions in Iceland in 2011. Road Transport accounts for 95.5% 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.

Activity Data

Total use of jet kerosene and gasoline is based on the NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion and the resulting emissions are given in Table 3.11.

Table 3.11. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from domestic aviation.

	1990	1995	2000	2005	2008	2009	2010	2011
Jet kerosene	8.409	8.253	7.728	7.390	7.601	6.271	6.066	6.027
Gasoline	1.681	1.131	1.102	0.872	0.731	0.649	0.648	0.411
Emissions	**32**	**30**	**28**	**26**	**26**	**22**	**21**	**20**

Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and are presented in Table 3.12. Emissions of SO_2 are calculated from S-content in the fuels.

Table 3.12. 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

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from domestic aviation is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%) and for CH_4 emissions it is 200% (with an activity data uncertainty of 5% and emission factor uncertainty of 200%). This can be seen in the quantitative uncertainty table in Annex II.

Planned Improvements

Planned improvements involve moving emission estimates from aviation to the Tier 2 methodology by next submission.

3.4.2 Road Vehicles

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

Activity Data

Total use of diesel oil and gasoline are based on the NEA's annual sales statistics for fossil fuels (Table 3.13).

Table 3.13. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from road transport.

	1990	1995	2000	2005	2008	2009	2010	2011
Gasoline	127.812	135.601	142.599	156.730	155.115	154.932	148.214	142.688
Diesel oil	36.567	36.862	47.463	83.478	113.964	114.491	106.433	106.293
Emissions	**529**	**561**	**633**	**800**	**891**	**892**	**844**	**824**

NEA estimates on how the fuel consumption is divided between different vehicles groups, i.e. passenger cars, light duty vehicles, and heavy duty vehicles are used for the period 1990 to 2005. From 2006 to 2011 EA estimated how the fuel consumption is divided between the different vehicles groups, using information on the number of vehicles in each group and the driven mileage in each group from the Road Traffic Directorate, using average fuel consumption based on the 1996 IPCC Guidelines regarding average fuel consumption per group. The data for 2006 to 2011 also contains information on motorcycles. The Road Traffic Directorate does not have similar data for previous years. Therefore the time series is not fully consistent as two different methodologies are used.

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

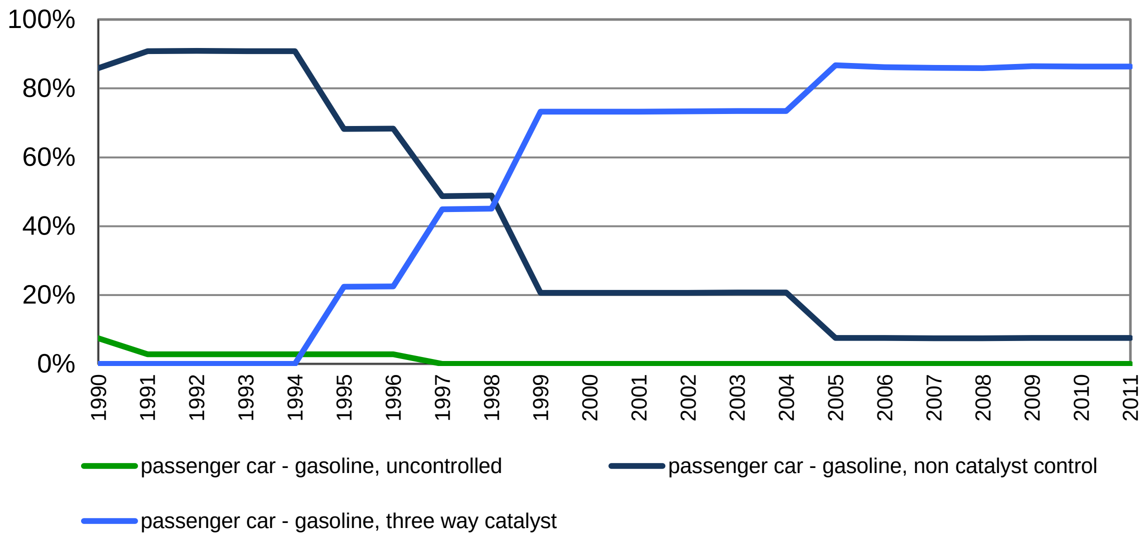

Figure 3.1. Passenger cars by emission control technology.

Emission Factors

Emission factors for 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 3.14.

Table 3.14. Emission factors for GHG from European vehicles, g/kg fuel.

	CH_4	N_2O	CO_2
Passenger car – gasoline, uncontrolled	0.8	0.06	3,180
Passenger car – gasoline, non catalyst control	1.1	0.08	3,180
Passenger car – gasoline, three way catalyst	0.3	0.8	3,180
Light duty vehicle – gasoline	0.8	0.06	3,180
Heavy duty vehicle – gasoline	0.7	0.04	3,180
Motorcycles - gasoline	5.0	0.07	3,180
Passenger car – diesel	0.08	0.2	3,140
Light duty vehicle – diesel	0.06	0.2	3,140
Heavy duty vehicle – diesel	0.2	0.1	3,140

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from road vehicles is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%). For N_2O, both activity data and emission factors are quite uncertain. The uncertainty of N_2O emissions from road vehicles is 50% (with an activity data uncertainty of 5% and emission factor uncertainty of 50%) and for CH_4 emissions it is 40% (with an activity data uncertainty of 5% and emission factor uncertainty of 40%). This can be seen in the quantitative uncertainty table in Annex II.

Planned Improvements

The EA made efforts to apply COPERT, a software tool used worldwide to calculate air pollutant and greenhouse gas emissions from road transport, between the 2012 and 2013 submissions. The use of the software requires annual data on the national vehicle fleet dissected by vehicle category, fuel type and emission control technology. To this end the EA contacted the Icelandic proprietor of this data, the Icelandic Road Traffic Directorate (IRTD) in the summer of 2012.

The IRTD informed the EA that the requested data could only be determined for a small fraction of the vehicle fleet, i.e. new cars (M1) imported since 2000. The IRTD also communicated that the categorization of other parts of the vehicle fleet, i.e. all cars imported before 2000, used cars imported since 2000, and all other vehicle types imported both new and used at any time, was not deemed possible, at least until further and extensive analyses which have not yet taken place due to a lack of resources. The EA cannot tell at this point in time if and when these extensive analyses will take place.

The EA also cooperated with Emisia, the producers of COPERT, by supplying them with Icelandic vehicle fleet data. Emisia will use the Icelandic data along with data from all 27 EU member states and some other countries and try to convert it into a kind of COPERT type dataset. This project will probably be finalized by the end of 2013 and could provide Iceland with data to improve its emission estimates from road transportation. The EA, however, recognizes that this approach is less desirable than the application of COPERT itself and will therefore put effort into working with the IRTD to initiate work on the data needed for COPERT.

3.4.3 National Navigation

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

Activity Data

Total use of residual fuel oil and gas/diesel oil for national navigation is based on NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion and the resulting emissions are given in Table 3.15.

Table 3.15. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from national navigation.

	1990	1995	2000	2005	2008	2009	2010	2011
Gas/Diesel oil	11.749	7.043	3.425	6.199	13.179	6.270	8.464	5.526
Residual fuel oil	7.170	4.755	0.542	0.881	4.192	3.709	2.612	0.330
Emissions	**60**	**37**	**13**	**23**	**55**	**32**	**35**	**19**

Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.16.

Table 3.16. 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

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from national navigation is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%). This can be seen in the quantitative uncertainty table in Annex II.

3.4.4 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, Keflavík Airport. Under normal circumstances almost all international flights depart and arrive from Keflavík Airport, except for flights to Greenland, the Faroe Islands, and some flights with private airplanes which depart/arrive from Reykjavík airport. Domestic flights sometimes depart from Keflavík airport in case of special weather conditions. Oil products sold to Keflavík airport are reported as international usage. The deviations between national and international usage are believed to level out. Emissions estimates for aviation will be moved to Tier 2 methodology by next submissions. A better methodology for the fuel split between international and domestic aviation will be developed in the near future as Iceland will take part in the EU ETS for aviation from 2012 onward and better data will become available. Emission factors for aviation bunkers are taken from the IPCC Guidelines and presented in Table 3.12 above.

The reported fuel use numbers are based on fuel sales data from the retail suppliers. The retail supplier divides their reported fuel sales between international navigation (including foreign fishing vessels) and national navigation based on identification numbers which differ between Icelandic and foreign companies. The emission factors for marine bunkers are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.16 above.

3.5 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 as well as in the Residential sector. Emissions from the Other sector accounted for 29.6% of the Energy sector's total and for 11.9% of total GHG emissions in Iceland 2011. Fishing accounted for 96.5% of the Other sector's total.

3.5.1 Commercial, Institutional, and Residential Fuel Combustion

The emissions from this sector are calculated by multiplying energy use with a pollutant specific emission factor.

Activity Data

Activity data is provided by the NEA, which collects data on fuel sales by sector. EA adjusts the data provided by the NEA as further explained in Annex III. Activity data for fuel combustion the Commercial/Institutional sector and the resulting emissions are given in Table 3.17.

Table 3.17. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the commercial/institutional sector.

	1990	1995	2000	2005	2008	2009	2010	2011
Gas/Diesel oil	1.8	1.6	1.6	1.0	0.3	0.3	0.3	0.3
Waste oil	3.3	-	-	-	-	-	-	-
LPG	0.3	0.3	0.5	0.5	0.1	0.1	0.2	0.2
Solid waste	-	0.5	0.6	0.5	0.4	0.4	0.4	0.2
Emissions	**12.3**	**6.3**	**6.8**	**4.9**	**1.5**	**1.4**	**1.7**	**1.6**

Activity data for fuel combustion in the Residential sector and the resulting emissions are given in Table 3.18. As can be seen in the table the use of kerosene has increased substantially the last four years. Kerosene is used in summerhouses, but also to some extent in the Commercial sector for heating of commercial buildings. The usage has been very low over the years and therefore the kerosene utilisation has all been allocated to the Residential sector. The increase in usage in the years 2008 to 2011 is believed to be attributed to rapidly rising fuel prices for the Transport sector. This has motivated some diesel car owners to use kerosene on their cars as the kerosene does not have CO_2 tax, despite the fact that it is not good for the engine.

Table 3.18. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the residential sector.

	1990	1995	2000	2005	2008	2009	2010	2011
Gas/Diesel oil	8.8	6.4	6.0	3.2	2.0	2.1	1.9	1.4
LPG	0.4	0.5	0.7	0.9	1.1	1.6	1.4	0.7
Kerosene	0.5	0.2	0.1	0.2	0.8	4.0	1.2	3.2
Emissions	**30.6**	**22.1**	**21.8**	**13.6**	**12.0**	**24.0**	**14.2**	**16.6**

Emission Factors

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 3.8 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. The CO_2 emission factor for waste incineration was calculated using Tier 2 methodology and default values from the 2006 GL. Therefore the waste amounts incinerated are dissected into eleven categories. The dry matter content, total, and fossil carbon fractions are calculated separately for each waste category and then added up. In years that have higher fractions of fossil carbon containing waste categories such as plastics the EF is higher than in other years since the EF is related to the total amount of waste incinerated. CO_2 EF varied between 0.44 and 0.69 t CO_2 per tonne waste (cf. chapter 8.4.3). The IEF for the sector shows fluctuations over the time series. From 1993 onwards waste has been incinerated to produce heat at two locations (swimming pools, school building). The IEF for waste is considerably higher than for liquid fuel. Further waste oil was used in the sector from 1990 to 1993. This combined explains the rise in IEF for the whole sector.

Recalculations

Activity data for kerosene was corrected for the year 2010. This led to an increase in emissions by 0.2 Gg CO_2 equivalents.

New waste composition data was incorporated which led to slightly higher fossil carbon content and slightly lower dry matter fraction of waste incinerated. The former change increased emissions by increasing CO_2 emissions whereas the latter change decreased emissions by reducing N_2O emissions whose EF is related to dry weight. For the years 1993-

2004, i.e. the years for which mean data of the time period 2005-2011 was used, this EF change meant a 5.3% emission increase of aggregated GHG emissions. For the time period from 2005-2010, i.e. the period during which annual data was used, the re-examination of waste composition data led to annual increases of aggregate emissions between 0.1% and 6.4%.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from Commercial/Institutional and Residential sector is 7% (with an activity data uncertainty of 5% and emission factor uncertainty of 5%), for CH_4 emissions it is 100% (with an activity data uncertainty of 5% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 5% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II.

3.5.2 Agriculture, Forestry, and Fishing

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

Activity Data

Total use of residual fuel oil and gas/diesel oil for the fishing is based on the NEA's annual sales statistics for fossil fuels. Activity data for fuel combustion in the Fishing sector and the resulting emissions are given in Table 3.19.

Table 3.19. Fuel use (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from the fishing sector.

	1990	1995	2000	2005	2007	2008	2009	2010
Gas/Diesel oil	174.9	191.3	211.1	171.7	129.1	127.7	144.7	128.2
Residual fuel oil	32.4	53.4	16.0	26.3	50.3	36.3	44.6	41.4
Emissions	**662.3**	**779.8**	**727.5**	**632.9**	**570.9**	**522.7**	**603.4**	**540.2**

Emission Factors

The emission factors are taken from the revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories for ocean-going ships and are presented in Table 3.16 above.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from fishing is 6% (with an activity data uncertainty of 3% and emission factor uncertainty of 5%), for CH_4 emissions it is 100% (with an activity data uncertainty of 3% and emission factor uncertainty of 100%), and for N_2O emissions it is 150% (with an activity data uncertainty of 3% and emission factor uncertainty of 150%). This can be seen in the quantitative uncertainty table in Annex II.

3.6 Cross-Cutting Issues

3.6.1 Sectoral versus Reference Approach

As explained in Chapter 1, a formal agreement has been made between the EA and the National Energy Authority (NEA) 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 every 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. As explained in Chapter 1.2.2 Act 70/2012 changes the form of relations between the EA and the NEA concerning data handling. The law states that the NEA among other institutions is obligated to collect data necessary for the GHG inventory and report it to the EA, further to be elaborated in regulations set by the Minister for the Environment and Natural Resources. The relevant regulation will be in place for the next inventory cycle and will clarify the role of NEA in the inventory process, so better data to use for the reference approach (energy balance) as well as better data for the fuel split for the sectoral approach will be obtained. The NEA has already started some projects to fulfil these commitments, with the aim to have a complete energy balance within two years.

Iceland is not a member of the International Energy Agency (IEA). The NEA has provided data to IEA on a voluntary basis. The data is provided in physical units and IEA uses its own conversion factors to estimate energy units. Further the IEA rounds the numbers provided by Iceland. In many cases the numbers are quite low so this rounding can have significant percentage difference. This explains partially the differences with the data used for the annual submission under UNFCCC.

3.6.2 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, which are accounted for under the Energy sector (Manufacturing industry and construction).

When compiling the data on import and export of fuels an error in the data has been discovered, as stocks of coking coal seem to have been building up since 2007 and at the same time as less import than use of coke has occurred. This can be explained by mistakes at the custom reports, where certain coke (imported cargo from Alabama) has been registered as coal instead of coke. Some mistakes seem to have occurred as well when registering steam coal and coking coal. As stated before the NEA is working on preparing an energy balance. In that work these issues will be tackled.

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.

3.7 Geothermal Energy (1B2)

3.7.1 Overview

Iceland relies heavily on geothermal energy for space heating (90%) and to a significant extent for electricity production (27% of the total electricity production in 2011). Geothermal energy is generally considered to have relatively low environmental impact. Emissions of CO_2 are commonly considered to be among the negative environmental effects of geothermal power production, even though they have been shown to be considerably less extensive than from fossil fuel power plants, or 19 times (Baldvinsson et al., 2011). Very small amounts of methane but considerable quantities of sulphur in the form of hydrogen sulphide (H_2S) are emitted from geothermal power plants.

3.7.2 Key Source Analysis

The key source analysis performed for 2011 has revealed that geothermal energy is a key source in terms of both level and trend, as indicated in Table 1.1.

3.7.3 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 of CO_2 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.

Emissions of CH_4 and H_2S are also calculated in a similar way that CO_2 is calculated, i.e. based on direct measurements. H_2S has been measured for the whole time series. Methane was measured in 2010 and 2011. Older measurements exist for the years 1995 to 1997. Based on these measurements an average methane emission factor was calculated and used for the years where no information has been provided. The methane emissions for those years (1995, 1996, 1997 and 2010) range from 35.5 to 55.8 kg/GWh, with an average of 45.7 kg/GWh.

Table 3.20 shows the electricity production with geothermal energy and the total CO_2, CH_4 and sulphur emissions (calculated as SO_2).

Table 3.20. Electricity production and emissions from geothermal energy in Iceland.

	1990	1995	2000	2005	2008	2009	2010	2011
Electricity production (GWh)	283	288	1323	1658	4037	4553	4465	4701
Carbon dioxide emissions (Gg)	61	82	153	116	184	168	189	179
Methane emissions (Gg CO_2 eq)	0.3	0.3	1.3	1.6	3.9	4.4	3.7	2.9
Sulphur emissions (as SO_2, Gg)	13	11	26	30	59	53	58	64

3.7.4 Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from geothermal energy is 10% (with an activity data uncertainty of 10% and emission factor uncertainty of 1%). The uncertainty of CH_4 emissions from geothermal energy is 10% (with an activity data uncertainty of 6% and emission factor uncertainty of 8%). This can be seen in the quantitative uncertainty table in Annex II.

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 equipment. The Industrial Process sector accounted for 41% of the GHG emissions in Iceland in 2011. By 2011, emissions from the industrial processes sector were 107% 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 92% of the sector's emissions in 2011. Figure 4.1 shows the location of major industrial plants in Iceland.

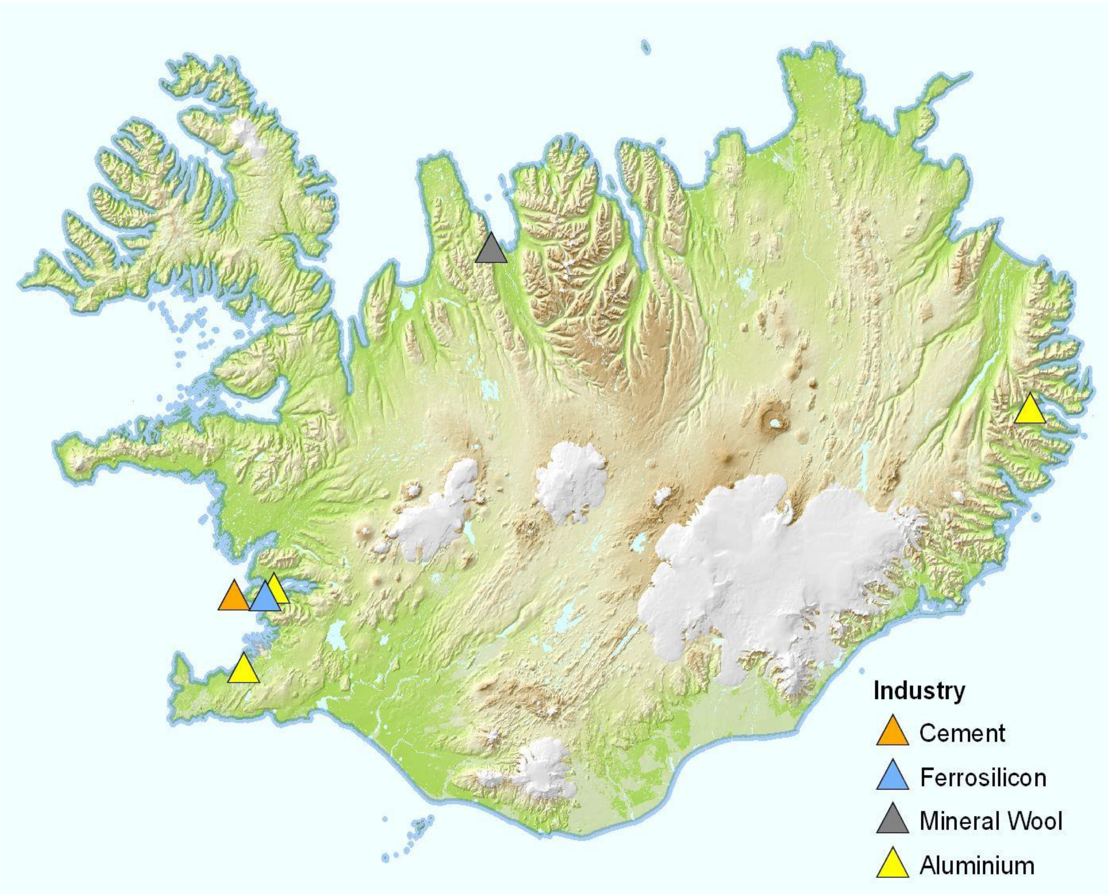

Figure 4.1. Location of major industrial sites in Iceland.

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 2011. Total CO_2 emissions from these projects amounted to 1,209 Gg and total emissions savings from the projects are 6,042 Gg. 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.

Recalculations were done for the Industrial Processes sector for this submission. CO_2 emissions from electrodes used at aluminium plants are now calculated by using plant and year specific carbon content of the electrodes. CO_2 emissions from the ferrosilicon plant are calculated with the mass balance approach using carbon content of the reducing agents, the product and non-product outgoing streams. This has led to minor increase in emissions. Further activity data for the mineral wool production was corrected for several years, based on new data collected directly from the single plant. Activity data for the food and drink production was also revised. Activity data and emission estimates for HFC were revised leading to changes in emissions.

4.1.1 Methodology

Greenhouse gas emissions from industrial processes are calculated according to methodologies suggested by the Revised 1996 IPCC Guidelines and the IPCC Good Practice Guidance.

4.1.2 Key Source Analysis

The key source analysis performed for 2011 has revealed the following greenhouse gas sources from the Industrial Processes Sector as key sources in terms of total level and/or trend (Table 1.1).

- Emissions from Mineral industry – CO_2 (2A)
  - This is a key source in level (1990) and trend.
- Emissions from Chemical industry – N_2O (2B)
  - This is a key source in level (1990).
- Emissions from Ferroalloys – CO_2 (2C2)
  - This is a key source in level (1990, 2011) and trend.
- Emissions from Aluminium Production – CO_2 (2C3)
  - This is a key source in level (1990, 2011) and trend.
- Emissions from Aluminium Production – PFCs (2C3)
  - This is a key source in level (1990, 2011) and trend
- Emissions from Consumption of halocarbons and SF_6 – HFCs (2F)
  - This is a key source in level (2011) and trend

4.1.3 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 Industrial Process 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**	**NO_x**	**CO**	**NMVOC**	**SO_2**
Mineral Products:										
Cement Production	E	NE	NE	NA	NA	NA	NE	NE	NE	IE[1]
Lime Production	NOT OCCURRING									
Limestone and Dolomite Use	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
Soda Ash Production and Use (IE)[2]	E	NA	NA	NA	NA	NA	NA	NA	NA	NA
Asphalt Roofing	NOT OCCURRING									
Road Paving with Asphalt	NE	NE	NE	NA	NA	NA	NA	NA	E	NA
Other (Mineral Wool Production)	E	NE	NE	NA	NA	NA	NE	E	NE	E
Chemical Industry										
Ammonia Production (IE)[3]	NA	NA	E	NA	NA	NA	E	NA	NA	NA
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	E	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									

1 SO_2 emissions from cement production are reported under the Energy sector, based on measurements.
2 Soda Ash was used at the Silicon plant which closed down in 2004, resulting CO_2 emissions from soda ash use are reported under silicon production.
3 Ammonia was produced at the fertilizer production plant that closed down in 2001. Resulting emissions of N_2O and NO_x are reported under fertilizer production.

4.1.4 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. 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 material, 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.

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

Where,

M_{cl} = Clinker production

EF_{cl} = Clinker emission factor; $EF_{cl} = 0.785 \times$ CaO content

CF_{ckd} = 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 from 2003 onwards. Historical clinker production data has been calculated as 85% of cement production, which was recommended by an expert at the cement plant. This ratio is close to the average proportion for the years 2003 and 2004.

Table 4.2. Clinker production and CO_2 emissions from cement production from 1990-2011.

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	64%	0.501	110%	63.2
2008	126,070	110,240	63.9%	0.502	110%	60.8
2009	59,290	51,864	63.9%	0.502	108%	28.1
2010	33,389	18,492	63.3%	0.497	108%	9.9
2011	38,048	35,441	64.2%	0.504	110%	19.6

Emission Factors

It has been estimated by an expert at the cement production plant that the CaO content of the clinker was 63% for all years from 1990 to 2006. From 2007 the CaO content is based on chemical analysis at the plant, as presented in Table 4.2. The corrected emission factor for CO_2 is thus 0.495 from 1990-2006, 0.501 in 2007, 0.502 in 2008 and 2009, 0.497 in 2010 and 0.504 in 2011. The correction factor for cement kiln dust (CKD) was 107.5% for all years from 1990 to 2004, 110% from 2005 – 2008 and 108% in 2009 and 2010. In 2011 the CKD correction factor was 110%.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from Cement Production is 8% (with an activity data uncertainty of 5% and emission factor uncertainty of 6.5%). This can be seen in the quantitative uncertainty table in Annex II.

4.2.2 Limestone and Dolomite Use (2A3)

Limestone has been used at the Elkem Iceland Ferrosilicon plant since 1999. Emissions are calculated based on the consumption of limestone and emission factors from the IPCC Guidelines. The consumption of limestone is collected from Elkem Iceland by EA through an electronic reporting form. The emission factor is 440 kg CO_2 per tonne limestone, assuming the fractional purity of the limestone is 1.

4.2.3 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 NMVOC are taken from Table 3.1, in chapter 2.A.6 in the EMEP/EEA emission inventory guidebook (2009). Emissions of SO_2, NO_x, and CO are expected to originate mainly from combustion and are therefore not estimated here but accounted for under sector 1A2f.

4.2.4 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. Production data for the years 1991 to 1995, 2003 and 2007 to 2010 was revised based on data collected directly from the single operating mineral wool plant. This influenced emissions of CO. Shell sand activity data was corrected for the years 2007 to 2010. This has led to minor changes in CO_2 emissions.

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, sludge containing silicium 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. The uncertainty of the CO_2 estimate is 3%, see Annex II.

When the fertilizer production plant was operational it reported its emissions of NO_x and N_2O to the EA. The uncertainty of the N_2O estimate is 50%, see Annex II.

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 are oxidized as part of the process to form CO_2 and silica dust. In the production raw ore, carbon material, and slag forming materials are mixed and heated to high temperatures for reduction and smelting. Ready-to-use iron pellets for the production are imported so no additional emissions occur from the iron part of the FeSi production. The carbon materials used are coal, coke, and wood. Electric (submerged) arc furnaces with Soederberg electrodes are used. The furnaces are semi-covered. Emissions 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 3 method from the 2006 IPCC Guidelines, based on the consumption of reducing agents and electrodes and plant specific carbon content. The amount of carbon in the ferrosilicon and coarse and fine microsilica is subtracted. The carbon content of electrodes and reducing agents is calculated by using equation 4.19 of the 2006 IPCC Guidelines, based on measurements at the plant. The IEF fluctuates over the time series depending on the consumption of different reducing agents and electrodes (3.08 – 3.52 t CO_2/t FeSi). CO_2 emissions resulting from the use of wood and charcoal are calculated but not included in national totals. Other emissions from the use of wood and charcoal are included in national totals.

Activity Data

The consumption of reducing agents and electrodes are collected from Elkem Iceland by EA through an electronic reporting form. Activity data for raw materials, products and the resulting emissions are given in Table 4.3.

Table 4.3. Raw materials (kt), production (kt) and resulting emissions (GHG total in Gg CO_2-equivalents) from Elkem.

	1990	1995	2000	2005	2008	2009	2010	2011
Electrodes	3.8	3.9	6.0	6.0	4.9	5.1	4.8	4.9
Coking coal	45.1	52.4	88.0	86.9	86.7	87.8	96.1	96.8
Coke oven coke	24.9	30.1	35.8	42.6	31.8	31.3	30.3	31.9
Char coal	-	-	-	2.1	0.2	0.2	-	-
Waste wood	16.7	7.7	16.2	15.6	14.2	16.4	11.3	7.4
Limestone	-	-	0.5	1.6	2.3	3.1	0.5	2.2
Production (FeSi)	62.8	71.4	108.4	111.0	96.4	98.0	102.2	105.2
Coarse Microsilica	0.9	1.0	1.4	1.6	1.3	1.3	1.1	1.2
Fine Microsilica	13.2	15.0	21.4	24.3	19.8	19.4	17.0	20.1
Emissions	**207**	**242**	**374**	**374**	**346**	**347**	**368**	**374**

Emission Factors

Emission factors for CO_2 are based on the carbon content of the reducing agents, electrodes, the ferrosilicon and microsilica. This information was taken from Elkem's application for free allowances under the EU ETS for the years 2005 to 2010. Upon request by the EA, Elkem also provided this information for the years 2000 to 2004 and 2011. Carbon content of coking coal, coke and charcoal are based on routine measurements of each lot at the plant. These measurements are available for the years 2000 to 2011. For the years 1990 to 1999 the average values for the years 2005 to 2010 were used. The carbon content of the electrodes is measured by the producer of the electrodes. Carbon content of waste wood is taken from a Norwegian report (*SINTEF. Data og informasjon om skogbruk og virke, Report OR 54.88).* Carbon content of products (ferrosilicon, coarse and fine microsilica) is based on measurements at the plant. The carbon content is presented in Table 4.4. The emission factor for the major source streams coal and coke are plant and year specific. The implied emission factor differs from year to year based on different carbon content of inputs and outputs as well as different composition of the reducing agents used, from 3.13 tonne CO_2 per tonne Ferrosilicon in 1998, to 3.60 tonne CO_2 per tonne Ferrosilicon in 2010.

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. Values for NCV are from the Good Practice Guidance. 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 Reference Manual of the 1996 IPCC Guidelines.

Table 4.4.Carbon content of raw material and products at Elkem.

	1990	1995	2000	2005	2008	2009	2010	2011
Electrodes	94%	94%	94%	94%	94%	94%	94%	94%
Coking coal	74.8%	74.8%	79.0%	75.5%	74.6%	74.6%	74.8%	75.2%
Coke oven coke	78.8%	78.8%	76.6%	73.8%	80.9%	80.3%	80.8%	79.7%
Char coal	-	-	-	80.9%	84.3%	82.0%	-	-
Waste wood	48.7%	48.7%	48.7%	48.7%	48.7%	48.7%	48.7%	48.7%
Production (FeSi)	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Coarse Microsilica	18%	18%	18%	18%	18%	18%	18%	18%
Fine Microsilica	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from ferroalloys production is 1.8% (with an activity data uncertainty of 1.5% and emission factor uncertainty of 1%). It is estimated that the uncertainty of the CH_4 emission factor is 100%. In combination with above mentioned activity data uncertainty this leads to a combined uncertainty of 100%. This can be seen in the quantitative uncertainty table in Annex II.

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.

Recalculations

Iceland joined the EU ETS for industry on the 1st January 2013. In its application for free allowances, Elkem provided comprehensive activity data and carbon content of inputs and outputs. The same data could also be provided for the years 2000 to 2004 and 2011. From this information it was possible to develop plant and year specific emission factors. This has led to minor increase in emissions, or by 3.3 Gg in 1990 and by 8.2 Gg in 2010.

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 3 method from the 2006 IPCC Guidelines, based on the quantity of electrodes used in the process and the plant and year specific carbon content of the electrodes.

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:

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

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. Activity data (production and information on anode effect) and the resulting emissions can be found in Table 4.5.

Table 4.5. Aluminium production, AE, CO_2, and PFC emissions from 1990-2011.

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	139.2	4.44	419.6	1.58	4.78
1991	89.217	142.0	3.63	348.3	1.59	3.90
1992	90.045	136.8	1.60	155.3	1.52	1.72
1993	94.152	141.6	0.74	74.9	1.50	0.80
1994	98.595	151.0	0.42	44.6	1.53	0.45
1995	100.198	154.0	0.55	58.84	1.54	0.59
1996	103.362	160.3	0.23	25.2	1.55	0.24
1997	123.562	192.8	0.62	82.4	1.56	0.67
1998	173.869	271.1	1.18	180.1	1.56	1.04
1999	222.014	354.3	0.63	173.2	1.60	0.78
2000	226.362	353.0	0.51	127.2	1.57	0.56
2001	244.148	382.4	0.35	91.7	1.57	0.38
2002	264.107	401.2	0.25	72.5	1.52	0.27
2003	266.611	410.2	0.21	59.8	1.54	0.22
2004	271.384	415.9	0.14	38.6	1.53	0.14
2005	272.488	417.1	0.08	26.1	1.53	0.10
2006	326.270	516.4	0.86	333.2	1.58	1.02
2007	455.761	693.0	0.46	281.3	1.52	0.62
2008	781.151	1186.8	0.33	349.0	1.52	0.45
2009	817.281	1231.5	0.17	152.7	1.51	0.19
2010	818.859	1237.6	0.14	145.6	1.51	0.18
2011	806.319	1214.3	0.07	63.2	1.51	0.08

Emission Factors

Emission factors for CO_2 are based on the plant and year specific carbon content of the electrodes. This information was taken from the aluminium plants' applications for free allowances under the EU ETS for the years 2005 to 2010. Upon request by the EA, the aluminium plants also provided information on carbon content of the electrodes for all other years in which the corresponding aluminium plant was operating in the time period 1990 to 2011. The weighted average carbon content of the electrodes ranges from 98.0% to 98.8%.

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.

Uncertainties

The estimate of quantitative uncertainty has revealed that the uncertainty of CO_2 emissions from aluminium production is 1.8% (with an activity data uncertainty of 1% and an emission factor uncertainty of 1.5%). This can be seen in the quantitative uncertainty table in Annex II.

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 7% for CF_4 and 22% for C_2F_6 (combining to an uncertainty of 9.3% for all PFC emissions from aluminium production).

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.

Recalculations

Iceland joined the EU ETS for industry on the 1st January 2013. In their application for free allowances, the aluminium plants provided comprehensive activity data and data on carbon content of electrodes. Upon request by the EA, the aluminium plants also provided information on carbon content of the electrodes for all other years in which the corresponding aluminium plant was operating in the time period 1990 to 2011. From this information it was possible to develop plant and year specific emission factors. This has led to minor increase in emissions, or by 2.7 Gg in 1990 and by 18.5 Gg in 2010.

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 8 million tonnes or on average at 1.6 million tonnes of carbon dioxide per year. Only parties where the total carbon dioxide emissions were less than 0.05% 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 2158.6 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% of the total carbon dioxide emissions of Annex I Parties in 1990, which is less than 0.05%. 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% 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 2,158.6 Gg. Industrial process carbon dioxide emissions from a single project which adds in any one year of the first commitment period more than 5% to the total carbon dioxide emissions in 1990, i.e. 107.9 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 2011, production in all three aluminium plants (Rio Tinto Alcan –the expanded part, Alcoa, and Century Aluminium) and in the ferrosilicon plant (Elkem, the expanded part). The total CO_2 emissions from these projects amounted to 1,209 Gg and total emissions savings from the projects are 6,274 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	Project IEF [CO_2 t/t]	Total PFC [Gg CO_2-eq]	Total IEF PFC [t CO_2-eq/t]	Total IEF CO_2 [CO_2 t/t]	Project Electricity [GWh]	Emission savings [Gg CO_2-eq]
Rio Tinto Alcan	128.8	6.0	1.514	2.8	0.02	1.472	1,315	773
Alcoa	514.3	23.8	1.509	22.6	0.07	1.509	4,797	2,820
Century Aluminium	421.9	19.5	1.505	33.3	0.12	1.505	4,164	2,448
Elkem	143.9	6.7	3.394	NA*	NA*	3.560	395	232
Total	**1,209**	**-**	**-**	**63.2**	**-**	**-**	**10,276**	**6,274**

**NA: Not Applicable.* 'Total IEF CO2' refers to IEF for the whole plant, i.e. the extended part and the existing part, whereas the 'Project IEF' refers only to the extended part. These only differ for the two plants that were in operation in 1990 (Rio Tinto Alcan and Elkem). 'Total IEF CO2' refers to IEF for the whole plant, i.e. the extended part and the existing part, whereas the 'Project IEF' refers only to the extended part.

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

0.010% of the electricity production. All electricity used in heavy industry is produced from renewable energy sources. Weighted average GHG emissions from electricity production in Iceland were 11.7 g/kWh in 2011.

For calculation of the resulting emission savings by using renewable energy, a comparison is made with a gas fired power plant. According to the International Aluminium Institute[1] the major part of the electrical power used in primary aluminium production in 2009, excluding hydropower and nuclear energy, is coal followed by gas. It can be assumed that if the aluminium would not be produced in Iceland using renewable energy, it would be produced with coal or gas energy. A conservative approach is to estimate emission savings in comparison with gas based electricity production.

The Icelandic legislature, Althingi, passed in 2007 an 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 2011, based on Decision 14/CP.7. Those are:

- expansion of the Rio Tinto Alcan Aluminium plant at Straumsvík,
- expansion of the Elkem Iceland Ferrosilicon plant at Grundartangi,
- establishment of the Century Aluminium plant at Grundartangi, and
- 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. How the projects adds more than 5% to the total carbon dioxide emission in 1990, i.e. more than 107.9 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 the best environmental practice (BEP) and best available technology (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

[1] http://www.world-aluminium.org/publications/

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 2011 185,267 tonnes of aluminium were produced compared to 100,198 tonnes in 1995. In 2011 the production increase resulting from this project amounted to 85,069 tonnes of aluminium (68,457 tonnes in potline 3 and 16,612 tonnes in potlines 1 and 2). The resulting emissions from the production of 85,069 tonnes of aluminium are 129 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990. In 2011 116,810 tonnes of aluminium were produced in potlines 1 and 2 leading to emissions of 168 Gg of CO_2. In potline 3 68,457 tonnes of aluminium were produced, leading to emissions of 105 Gg of CO_2. Total CO_2 emissions from the plant were thus 280 Gg.

3. In 2011 the plant used 2,864 GWh of electricity, thereof 1,315 GWh were used for producing the 85,069 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 11.7 g CO_2/kWh. Total CO_2 emissions from the electricity used for the project amounts to 15 Gg. Typical emissions from a gas fired power plant amount to 600 g CO_2/kWh[2]. The emissions from electricity use in the project would therefore have equalled 789 Gg had the energy been from natural gas and not from renewable sources. The resulting emissions savings are 773 Gg.

4. Best available techniques (BAT), 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.

    Best environmental practice (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 185,267 tonnes of aluminium at Rio Tinto Alcan were 280.1 Gg CO_2-equivalents in 2011, 272.8 Gg of CO_2 from electrodes

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

consumption and 7.4 Gg CO_2-equivalents of PFCs due to anode effects. The resulting IEF are 1.472 tonnes CO_2 per tonne of aluminium and 0.04 tonnes of PFC in CO_2-equivalents per tonne of aluminium. For comparison, the median value of PFC emissions in 2009 for prebake plants worldwide was 0.34 CO_2-equivalents per tonne of aluminium[3]. Besides that 9.5 Gg were emitted from fuel combustion. The IEF for fuel use is 0.05 t CO_2-equivalents 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. The iron comes from imported ready-to-use iron pellets. Electric (submerged) arc furnaces with Soederberg electrodes are used. All furnaces are semi-covered. It is not possible to use wood in Furnace 3.

2. In 1990 62,792 tonnes were produced leading to emissions of 207 Gg of CO_2. In 2011 105,193 tonnes were produced (26,690 tonnes in furnace 1; 34,445 tonnes in furnace 2; and 44,059 tonnes in furnace 3) leading to emissions of 374 Gg of CO_2 (98, 125 and 144 Gg in furnace 1, 2 and 3 respectively). The production falling under Decision 14/CP.7 is thus 44,059 tonnes of ferrosilicon (all production in furnace 3; the production increase since 1990 is less than the production in furnace 3). This production leads to emissions of 144 Gg of CO_2. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2011 the plant used 944 GWh of electricity, thereof 395 GWh were used for the production increase since 1990 (44,059 tonnes of ferrosilicon). All the electricity used for the production comes from renewable sources. The average CO_2 emissions from producing this electricity are 11.7 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 4.9 Gg. Had the energy been from a gas fired power plant the emissions would amount to 600 g/kWh. The resulting emissions from electricity use in the project would in this case have amounted to 237 Gg CO_2. Emissions savings from using renewable energy for the project are 232 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 the plant has an environmental management plan as a part of a certified ISO 9001 quality management system, meeting the requirement of BEP.

[3] International Aluminium Institute: http://world-aluminium.org/cache/fl0000342.pdf

5. Total process emissions from production of 105,193 tonnes of ferrosilicon at Elkem Iceland in 2011 were 374 Gg CO_2-equivalents. The resulting IEF are 3.560 tonnes CO_2 per tonne of ferrosilicon. Besides that 1.2 Gg CO_2 were emitted from fuel combustion. The IEF for fuel use is 0.011 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 2011 the Century Aluminium plant produced 280,300 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 422 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2011 the plant used 4,164 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 11.7 g/kWh. The resulting total CO_2 emissions from the electricity use are 49 Gg. Had the energy been from a gas fired power plant the emissions would have amounted to approximately 600 g/kWh, resulting in emissions from electricity use in the project equivalent to 2,497 Gg. Emissions savings from using renewable energy equal 2,448 Gg.

4. Best available techniques (BAT), as defined by the IPPC, are applied at the Century Aluminium plant as stipulated in the operating permit. Century Aluminium is implementing an environmental management system according to ISO 14001. The environmental management system will be certified in the autumn of 2013.

5. Total process emissions from production of 280,300 tonnes of aluminium at Century Aluminium in 2011 were 455 Gg CO_2-equivalents, 422 Gg of CO_2 from electrodes consumption and 33 Gg CO_2-equivalents of PFCs due to anode effect. The resulting IEF are 1.505 tonnes CO_2 per tonne of aluminium and 0.12 tonnes of PFC in CO_2-equivalents per tonne of aluminium. Besides that 2.2 Gg were emitted from fuel combustion. The IEF for fuel use is 0.008 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. Since then, small capacity increase has occurred. In 2011 352,781 tonnes of aluminium were produced at the plant. The Alcoa Aluminium plant is a single project as defined in Decision 14/CP.7.

2. In 2011 the Alcoa Aluminium plant produced 340,752 tonnes of aluminium. The resulting industrial process carbon dioxide emission amounted to 514 Gg. This amount adds more than 5% to the total carbon dioxide emissions in 1990.

3. In 2011 the plant used 4,797 GWh of electricity, all from renewable sources. Average emissions from producing this electricity are equivalent to 11.7 g/kWh. The resulting total CO_2 emissions from the electricity use are 56 Gg. Had the energy been from a

gas fired power plant the emissions would amount to approximately 600 g/kWh, resulting in emissions from electricity use in the project equivalent to 2,876 Gg. Emissions savings from using renewable energy equal 2,820 Gg.

4. Best available techniques (BAT), as defined by the IPPC, are applied at the Alcoa Aluminium plant as stipulated in the operating permit. Alcoa Fjarðaál has implemented an ISO 14001 environmental management system. The environmental management system was certified in 2012.

5. Total process emissions from production of 340,752 tonnes of aluminium at Alcoa Fjarðaál in 2011 were 537 Gg CO_2-equivalents, 514 Gg of CO_2 from consumption of electrodes and 23 Gg CO_2-equivalents of PFCs due to anode effect. The resulting IEF are 1.509 tonnes CO_2 per tonne of aluminium and 0.07 tonnes of PFC in CO_2-equivalents per tonne of aluminium. Besides that, 2.1 Gg were emitted from fuel combustion. The IEF for fuel use is 0.006 t CO_2-equivalents per tonne of aluminium.

4.6 Other Production (2D)

Other production in Iceland is the Food and Drink Industry. NMVOC emissions from this sector are estimated. Production statistics were obtained by Statistics Iceland for beer, fish, meat and poultry for the whole time series (Figure 4.2). Statistics for coffee roasting and animal feed were available for the years 2005 to 2010. Production statistics were extrapolated for the years 1990 to 2004. For this submission production statistics for fish, meat and poultry were corrected. Further production of bread, cakes and biscuits was estimated from consumption figures (Þorgeirsdóttir et al., 2012). Emission factor for NMVOC were taken from Tables 2-24 and 2-25 in the 1996 IPCC Guidelines.

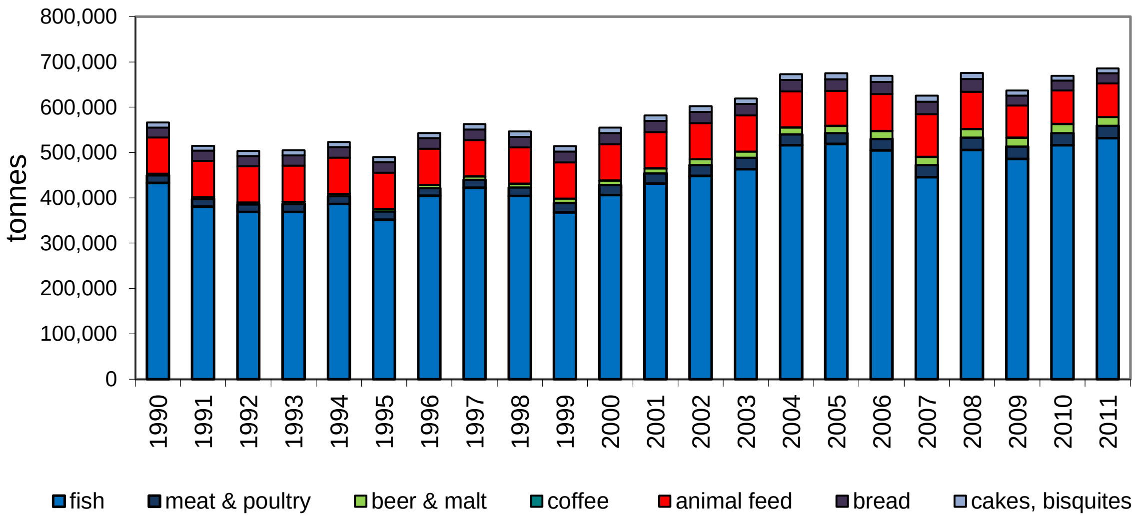

Figure 4.2. Food and drink production in Iceland.

4.7 Production of Halocarbons and SF_6 (2E)

There is no production of halocarbons or sulphur hexafluoride (SF_6) in Iceland.

4.8 Consumption of Halocarbons and SF_6 (2F)

4.8.1 Consumption of Halocarbons

Overview

In Iceland hydrofluorocarbons (HFCs) are used first and foremost as refrigerants. HFCs substitute ozone depleting substances like the chlorofluorocarbon (CFC) R-12 and the hydrochlorofluorocarbons (HCFCs) R-22 and R-502, which are being phased out by the Montreal Protocol. HFCs were first introduced to Iceland in 1993. Fluorinated gases have been regulated since 1998 and are banned for certain uses. These uses include:

- Use in fire protection (2F3)
- Use as aerosols (2F4) with the exception of metered dose inhalers (MDIs)
- Use as solvents (2F5)

The use of HFCs in the refrigeration and air conditioning sector (2F1) spans the following applications:

- domestic refrigeration,
- commercial refrigeration,
- transport refrigeration,
- industrial refrigeration,
- residential and commercial A/C, including heat pumps
- mobile air conditioning (MAC).

HFCs are also used in metered dose inhalers (2F4). Use of HFCs in other sub-source categories is not occurring. The structure of the source category consumption of Halocarbons is shown in Table 4.7.

Table 4.7. Source category structure of HFC consumption

GHG source category	GHG sub-source category	Further specification
2F1 Refrigeration	Domestic refrigeration	
	Commercial refrigeration	Combination of stand-alone and medium & large commercial refrigeration
	Transport refrigeration	Reefers
		Fishing vessels
	Industrial refrigeration	
	Stationary Air-conditioning	
	Mobile air conditioning (MAC)	Passenger cars
		Trucks
		Coaches
2F4 Aerosols	Metered dose inhalers (MDI)	

The commercial fishing industry is one of Iceland´s most important industry sectors, yielding total annual catches between one and two million tonnes since 1990. Directly after catch and processing, fish is either cooled or frozen and shipped to the market. A substantial part of the Icelandic fleet replaced refrigeration systems that used CFCs and HCFCs as refrigerants by systems that use ammonia. Especially smaller ships, however, retrofitted their systems with HFCs due to the fact that the additional space requirements of ammonia based systems exceeded available space.

The phase of retrofitting and replacing refrigerant systems in the fishing industry is still on-going. The ban on importing new R-22, which became effective in 2010 and the impending ban on importing recovered R-22 mean a price increase for R-22 and add urgency to the process.

Refrigeration systems onboard ships are fundamentally different from systems on land regarding their susceptibility to leakage. Therefore they are allocated to transport refrigeration, as are refrigerated containers (reefers). Industrial refrigeration, on the other hand, comprises refrigeration systems used in food industries such as fish farming, meat processing, and vegetable production.

The HFCs most commonly used in Iceland are HFC-125, HFC-134a, and HFC-143a. They are imported in bulk and in equipment such as domestic refrigerators, vehicle air conditionings, reefers, and MDIs. All other HFCs are imported in bulk only.

In this chapter the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 34 is used to label HCFCs and HFCs (ASHRAE, 2007). It consists of the letter R and additional numbers and letters. HFC notations are used later on when the R-blends have been disaggregated by calculations into the HFCs contained in them.

Methodology

Emissions for the refrigeration and air conditioning sector are estimated using the GPG Tier 2a – Bottom-up approach. For some sectors, however, the approach had to be modified since no information on the amount of units and their average charge could be collected. Instead the bulk import of HFCs was allocated to sub-source categories based on expert judgement. This will be explained in more detail in the chapter on activity data. Emissions from MDIs are calculated using equation 3.35 in the GPG.

Source specific QA/QC procedures

The spread sheets employed in the calculation of HFC emissions from refrigeration and air conditioning equipment were designed thus that they included error diagnoses and control mechanisms. An example for such a control mechanism is the comparison between the HFC amounts imported for a certain refrigeration sub-source until 2011 and the sum of all sub-source emissions until 2011 and the amount allocated to the sub-sources 2012 stock. This difference had to be zero.

Activity data

Refrigeration and air conditioning

All HFCs used in Iceland are imported, the majority of which in bulk. The amounts imported are recorded by Customs Iceland whence it is reported to the EA. Since 1995 importers also have to apply at the EA for permits to import HFCs. R-134A and R-404A are also imported in equipment such as reefers, vehicle ACs, and domestic refrigerators.

Information on the amount of reefers in stock along with information on the sort of refrigerants contained in them was obtained from major stakeholders. During the 1990s R-12 in reefers was replaced by R-134A. Today reefers contain either R-134A or R-404A. The average refrigerant charge per reefer is 5 kg refrigerant. Due to the limited amount of stakeholders involved in the sector, further information is confidential.

Information on registered vehicles was obtained from the Road Traffic Directorate. This data consisted of annual information dating back to 1995 on the number of registered vehicles subdivided by vehicle classes and their first registration year. Vehicle classes were aggregated based on estimated refrigerant charges:

- EU classes M1, M2, and N1: GPG default of 0.8 kg for passenger cars
- EU classes N2 and N3 (trucks): GPG default of 1.2 kg for trucks
- EU class M3 (coaches): country specific value of 10 kg (expert judgement)

The information on vehicles' first registration years was used to estimate the amount of vehicles equipped with (R-134A containing) MACs. Based on a study by the EU (Schwarz et al., 2011) it is assumed that 80% of all vehicles manufactured today (i.e. since 2010) contain MACs. This value was reduced linearly to 5% in 1995, the first year in which the automobile industry used R-134A in new vehicles.

Based on expert judgement it is assumed that all domestic refrigerators imported to Iceland from the US since 1993 contain R-134A as refrigerant whereas refrigerators from elsewhere contain non-HFC refrigerants. The average charge per refrigerator is estimated at 0.25 kg. This estimation is in line with the range given by the GPG: 0.05-0.5 kg (Table 3.22 on page 3.106).

The bulk import of refrigerants is subdivided thusly into the following applications:

- All R-407C and R-410A amounts are allocated to Residential and Commercial AC, including heat pumps.
- Since reefers are refilled, the amount of R-134A and R-404A leaking from reefers is replaced by corresponding amounts of imported R-134A and R-404A.
- 65% of the import of each remaining refrigerant - all refrigerants with the exceptions of R-407C, R-410A and fractions of R-134A and R-404A - are allocated to fishing vessels (transport refrigeration)
- 20% of all remaining refrigerants are allocated to industrial refrigeration
- 15% of all remaining refrigerants are allocated to commercial refrigeration

This division is based on two sources of information: A) sales data supplied by the main importers of refrigerants as well as B) a poll of the majority of companies designing, installing and servicing a broad range of refrigeration systems. Nevertheless is the EA aware that this method simplifies the sector. Figure 4.3 shows the quantity of HFCs introduced to Iceland in bulk between 1993 and 2011.

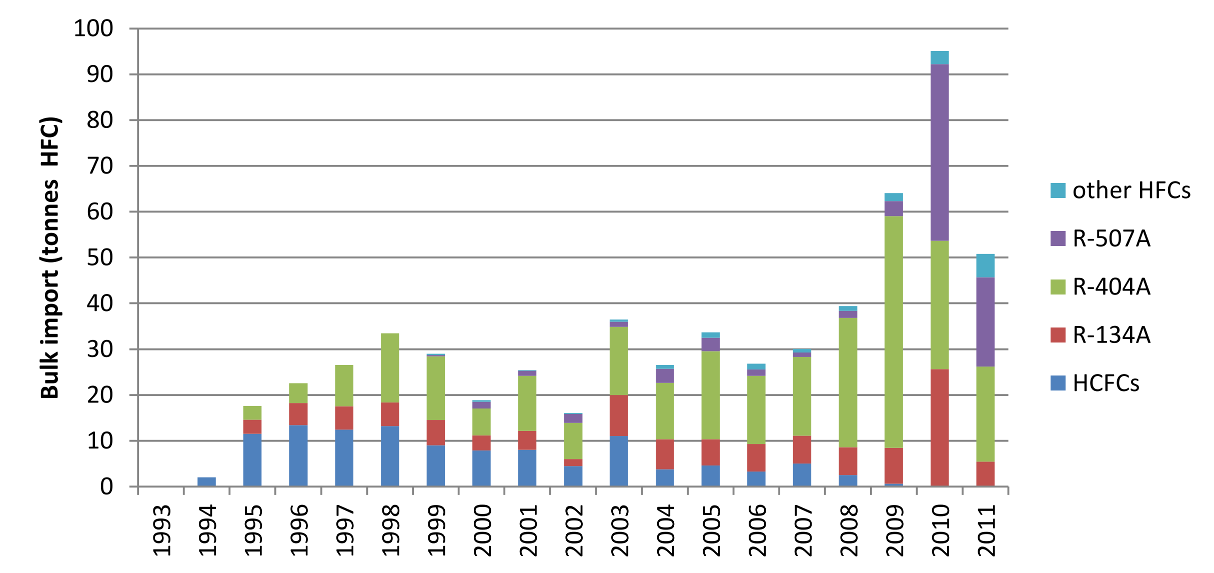

Figure 4.3. Quantity of HFCs introduced in bulk to Iceland between 1993 and 2011.

The Icelandic Medicines Agency records import of MDIs containing R-134A since 2002. The amount of R-134A in MDIs has been oscillating between 500 and 650 kg since that time.

Emission factors

Total emissions from refrigeration and air conditioning equipment are calculated using equation 3.39 from the GPG (p. 3.100).

EQUATION 3.39

Total Emissions = Assembly Emissions + Operation Emissions + Disposal Emissions

Assembly emissions include the emissions associated with product manufacturing, even if the products are eventually exported.

Operation emissions include annual leakage from equipment stock in use as well as servicing emissions. This calculation should include all equipment units in the country, regardless of where they were manufactured.

Disposal emissions include the amount of refrigerant released from scrapped systems. As with operation emissions, they should include all equipment units in the country where they were scrapped, regardless of where they were manufactured.

Assembly emissions are calculated by multiplying the amount of HFC and PFC in the initial charge with an emission factor k that represents the percentage of initial charge that is released during assembly of the e.g. refrigeration system (equation 3.41 in the GPG). Sub-source values used as k are presented in Table 4.8.

Operation emissions are calculated by multiplying the amount of HFC and PFC in stock with an annual leak rate x (equation 3.42 in the GPG).Sub-source values used for x are shown in Table 4.8.

The calculation of disposal emissions requires information on the average lifetime n of equipment. The average lifetime is not only necessary to allocate disposal emissions to an appropriate year but also to estimate the charge remaining in equipment (y) by continually discounting the original charge with n years. If refrigerants are recovered during disposal, the disposal emissions have to be reduced with a recovery efficiency factor z. This factor will be zero if no refrigerant recycling takes place. Recovery efficiency factors used are also shown in Table 4.8. The equation for disposal emissions is shown below:

EQUATION 3.43

Disposal Emissions = (HFC and PFC Charged in year t – n) • (y / 100) • (1 – z / 100) – (Amount of Intentional Destruction)

Table 4.8. Values used for charge, lifetime and emission factors for stationary refrigeration equipment and mobile air conditioning. Sources for the majority of values are GPG Tables 3.22 and 3.23 on pages 3.106 and 3.110.

Application	HFC charge (kg/unit)	Lifetime n (years)	Initial EF k (% of initial charge)	Lifetime EF x (%/year)	End-of-life EF z (% recovery efficiency)
Domestic refrigeration	0.25	12	NO	0.3%	70%
Commercial refrigeration	NE	9	2%	10%	80%
Transport ref.: reefers	5	NE	NO	15%	NE
Transport ref.: fishing vessels	NE	7	1%	Linear decrease from 50% in 1993 to 20% in 2012	75%
Industrial refrigeration	NE	15	2%	10%	85%
Residential AC	NE	12	1%	3%	75%
MAC: passenger cars	0.8	14	NO	10%	0%
MAC: trucks	1.2	14	NO	10%	0%
MAC: coaches	10	14	NO	10%	0%

The lifetime for domestic refrigerators is at the lower end of the range given by the GPG. The lifetime EF and the efficiency of recovery at end of life are GPG default values. Initial emissions are not occurring since domestic refrigeration equipment is assembled prior to import. The same applies as well to reefers and MACs. Transport refrigeration equipment on fishing vessels, commercial and industrial refrigeration equipment as well as residential ACs - on the other hand - are assembled on site and are therefore attributed with initial EFs. These initial EFs as well as lifetimes for other sub-source categories are taken from the ranges given in the GPG. Stand-alone and medium & large commercial refrigeration are combined into one sub-source. Both commercial and industrial refrigeration lifetime EFs are estimated at 10%. Thus they are in the lower half of the ranges given by the GPG (both commercial applications together have a lifetime EF range from 1-30%). The value was chosen based on information from the poll of the Icelandic refrigeration sector mentioned above.

Leakage on shipping vessels has decreased to a considerable extent in the last decades. This is mainly a consequence of the higher prices of HFC refrigerants compared to the prices of their predecessors. Higher refrigerant prices make leakage detection and reduction more feasible. The employments of leak detectors and routine leakage searches have become common practice on fishing vessels. Therefore it can be assumed that the lifetime EF of shipping vessels has been decreasing since the introduction of HFCs. The lifetime EF of shipping vessels for the beginning of the period is assumed to be at the upper end of the range for transport refrigeration (50%). This EF is lowered linearly to 20% in 2012. The latter value was determined after evaluation of information from the above mentioned poll.

Values for residential AC are default values given by the GPG as are the recovery efficiencies for all applications.

No HFC charge amounts are given for commercial refrigeration, fishing vessels, industrial refrigeration and residential AC. No information exists on the average charge and the number of units for these sub-source categories. Therefore the bottom-up approach was modified. Instead of estimating sub-source specific HFC amounts by multiplying units with their average charge, imported HFC bulk amounts were divided between sub-sources using fractions (cf. explanations above). The bulk import is then treated as the equipment in which it is contained thus that it is attributed with a sub-source specific lifetime n. After n years the part of initially imported HFC not yet emitted is disposed of or rather recovered. The poll revealed that the majority of refrigerants are recovered. Therefore it is assumed that the share not lost during recovery (1-z) is reused thus remaining in the same sub-source´s stock.

Reefers are periodically refilled. Therefore their initial charge is deemed constant and the amount emitted (and refilled) is subtracted from the amounts of R-134A and R-404A imported in bulk during the same year. Based on expert judgment the lifetime EF for reefers is estimated to be 15%. This method implies end-of-life emissions in lifetime emissions: by assuming refill the charge of each reefer is renewed every 6-7 years.

The lifetime of vehicles is based on information collected by the Icelandic recycling fund. The average age of vehicles at end-of-life is 14 years. The lifetime EF is at the lower end of the range given in the GPG. This is justified by the prevailing cold temperate climate which limits AC use. The recovery efficiency is set to zero since no refrigerant recovery takes place when vehicles are prepared for destruction.

According to GPG methodology it is good practice to use an EF of 50% for MDIs. This entails that 50% of R-134A imported in MDIs is emitted during the import year, whereas the remaining 50% are emitted during the following year along with 50% of that following year´s import.

Emissions

Emitted refrigerants are dissected into constituent HFCs. HFC emissions are aggregated by multiplying individual HFCs with respective GWPs leading to totals in CO_2 eq. All values and fractions below relate to aggregated emissions expressed in CO_2 eq.

Total emissions from all refrigeration and air conditioning equipment amounted to 120.5 Gg in 2011 which is a 1% decrease compared to 2010 (Figure 4.4). This slight decrease is due to a pronounced decrease in the quantity of imported HFCs between 2010 and 2011.

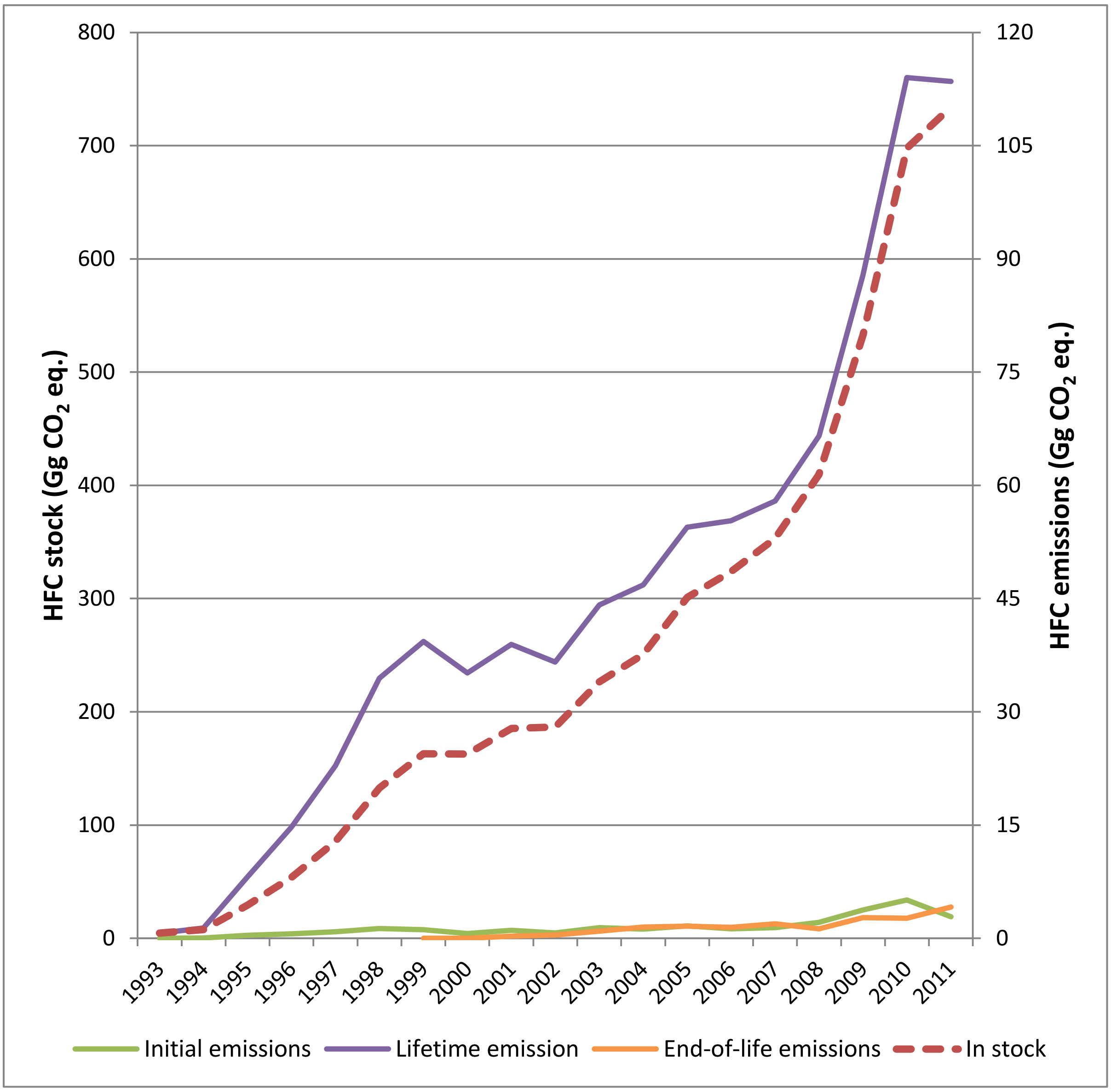

Figure 4.4. HFC stock (primary y-axis) and emissions (secondary y-axis) from refrigeration and air conditioning equipment. Included are domestic refrigeration, commercial refrigeration, industrial refrigeration (fishing vessels and reefers), residential ACs, and MACs.

Lifetime emissions are 94.2% of emissions, 3.4% are end-of-life emissions and 2.4% are initial emissions. The low fraction of initial emissions is mainly caused by comparably low initial EFs and to a lesser extent by the fact that equipment of some sub-sources is assembled outside Iceland. The low fraction of end-of-life emissions is caused by the fact that the majority of refrigerants are recovered at-end-of-life. Another factor is the fact that the amount of imported HFCs has been steadily increasing since their introduction. The amount of equipment being retired now, i.e. equipment imported or installed during the late 90s and early 2000s is therefore comparatively low. This also means that end-of-life emissions will increase in years to come.

Almost two thirds of emissions stem from refrigeration systems on fishing vessels. Total transport refrigeration emissions, i.e. including reefers, account for nearly 70% of all HFC emissions. Other important sectors are industrial refrigeration (14.9%), commercial refrigeration (11.5%), and MACs (4.7%). Residential AC emission shares are within 1% of total refrigeration and AC emissions due to low EFs and no sub-source HFC import until 1999. Emissions from domestic refrigeration constitute less than 0.1% of total refrigeration emissions due to the insignificance of imported refrigerant amounts (Figure 4.5).

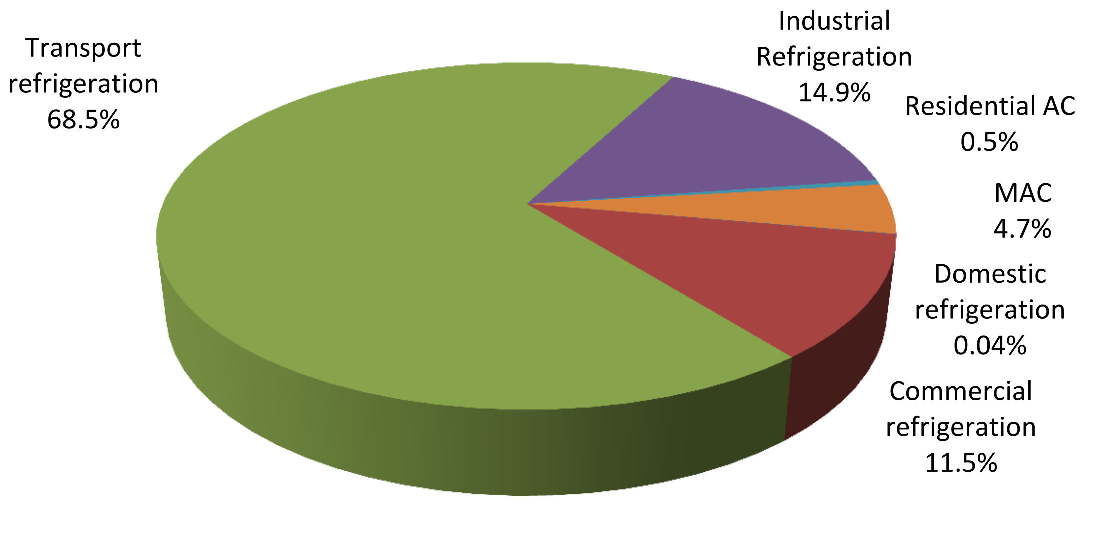

Figure 4.5. 2011 emission distribution of refrigeration and AC sub-source categories.

The relations between imports, stock development and emission trends are shown for fishing vessels and MAC hereafter. The stock of HFCs in refrigeration systems on fishing vessels (Figure 4.6) shows a distinct increase between 2007 and 2010 caused by a stark import increase of especially R-404A and R-507A, two refrigerants with high GWPs. The above mentioned import decrease between 2010 and 2011 slows the growth of the sub-source´s HFC stock. Lifetime emissions decrease between 2010 and 2011 (although the stock is still growing slightly) because the EF is being decreased from 24.7% to 23.2% between years. End-of-life emissions start in 1999 when the first equipment containing HFC imported in 1993 is retired (after emitting lifetime emissions for 7 years). The graphs for commercial and industrial refrigeration show the same trends on different scales and with different onset years for end-of-life emissions.

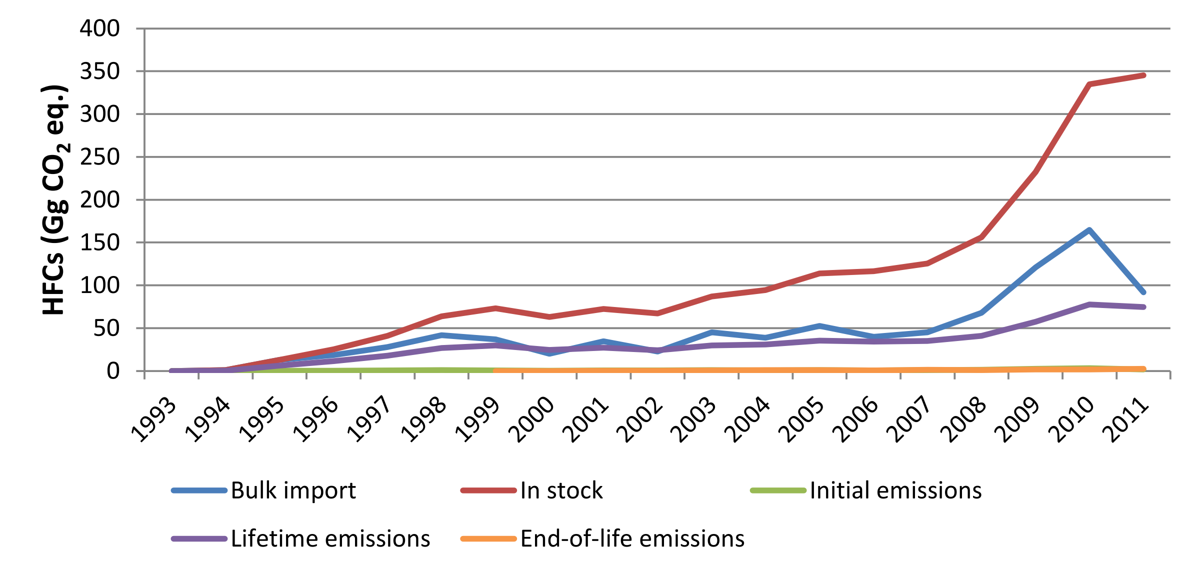

Figure 4.6. Import, stock development and emissions from refrigeration systems on fishing vessels between 1993 and 2011.

The graph for MACs (Figure 4.7) does not show import quantities since information exists on the vehicle stock. HFC amount in stock rises between 1995 and 2007 not only because of the assumed linear increase in the share of vehicles with ACs but also because of a 75% increase in fleet size. Since 2007 the fleet size has been more or less stagnant at around 240,000 vehicles. The stable fleet size, in interaction with a stagnant vehicle AC share of 80% since 2010, leads to a decrease in stock caused by the precedence of lifetime emissions over additions to the stock in form of new vehicles.

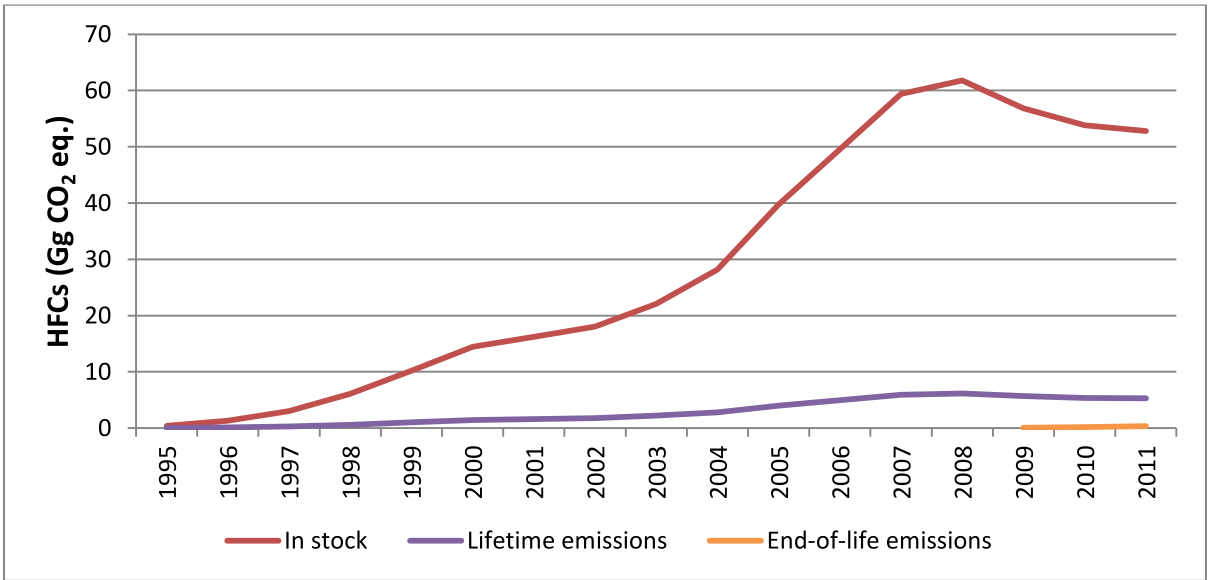

Figure 4.7. Emissions from mobile air conditionings.

Emissions from MDIs increased from 0.77 Gg CO2 eq. in 2010 to 0.82 Gg CO2 eq. in 2011 or by 7% due to increasing import in equipment.

Uncertainties

Emission factor uncertainty of the refrigeration and air conditioning sector were calculated by relating the lifetime emission factor ranges given in tables 3.22 and 3.23 to the respective values used. Initial and end-of-life emission factors were not considered since they play a very minor role when compared to lifetime emissions and activity data uncertainty. The only exception to this rule is domestic refrigeration where end-of-life emissions outweigh lifetime emissions. Their relative share of total refrigeration emissions, however, is only 0.04%.

AD uncertainty was estimated by expert judgement and is deemed to be a factor of one or two for most sub-source categories. In order to comply with the methodology of uncertainty calculations for the inventory as a whole, sub-source EF and AD uncertainties were first summarized separately by weighting them with 2011 emission quantities. The resulting EF and AD certainties were then combined by multiplication (equation 6.4 on page 6.12 of the GPG). Uncertainty factors are summarized in Table 4.9.

Table 4.9. Lifetime EFs used along with EF ranges given in the GPG; calculated EF uncertainties and estimated AD uncertainties as well as 2011 emission shares used to weight uncertainties.

Value ranges (Lifetime EF)	EF, lower bound	EF, upper bound	Lifetime EF used	EF uncertainty	AD uncertainty	2011 emission share	Combined unceratinty
Domestic ref.	0.1	0.5	0.3	200	500	0.0%	
Commercial ref.	5.5	20	10	100	200	11.5%	
Fishing vessels	15	50	35	133	200	C	
Reefers	5	20	10	100	50	C	
Industrial ref.	7	25	10	150	100	14.9%	
Residential AC	1	5	3	200	200	0.5%	
MAC	10	20	10	100	100	4.7%	
Weighted uncertainties				130	176		219

Uncertainty of HFC emissions from MDIs was not calculated separately. Although uncertainty of emission estimates for MDIs is deemed less than uncertainty of emission estimates for refrigeration subsector uncertainty, it is implied in total HFC consumption uncertainty. This is justified by the relative insignificance of MDI emissions compared to refrigeration emissions.

Recalculations and improvements

The estimation of emissions from consumption of HFCs has undergone major changes between the 2012 and 2013 submissions. The most important changes are listed below:

- The number of refrigeration and air conditioning sub-sources was increased from three in the 2012 submission (domestic and commercial refrigeration, MACs) to six in the 2013 submission (transport and industrial refrigeration as well as residential AC were added). These additions are based on more information about and a better understanding of the Icelandic refrigeration sector.
- Concomitant with the addition of new sources was an allocation diversification of HFC bulk import. In the 2012 submission all bulk import with the exception of 5% of the imported R-134A quantity was allocated to commercial refrigeration, the

remainder was allocated to MACs. In the 2013 submission bulk import was allocated to all sub-sources with the exception of MACs.

- HFC stock of and emissions originating from refrigerated containers were recorded for the first time
- Initial emissions and end-of-life emissions were estimated for the first time in the 2013 submission.
- The lifetime emission factor for commercial refrigeration stayed unchanged. However, the lifetime EF of transport refrigeration, the sub-source now receiving the bulk of imported HFC quantities, was assessed as being considerably higher, i.e. 50% in 1993 and then linearly decreasing to 23.2% in 2010.

Total HFC emissions from refrigeration and air conditioning equipment for the year 2010 were estimated at 122 Gg CO_2 eq. in the 2013 emission which is a 54 Gg or 78% increase from the estimate in the 2012 submission (68 Gg CO_2 eq.). One third of this increase can be attributed to the correction of a calculation error in last year´s submission, which allocated the first lifetime emissions of imported HFC to the year following the import year instead of the import year itself. Around 50% of the increase is caused by increasing the lifetime emission factor for the bulk of the HFC quantity imported to Iceland. Other, more minor factors increasing HFC emission estimates are the addition of initial and end-of-life emissions, the detection of emissions from refrigerated containers, and the increased estimate regarding the amount of MACs in the Icelandic vehicle fleet, which increases the emissions from MACs by 44% (in combination with increasing charge sizes for trucks and coaches). Emissions from the domestic refrigeration sector increased almost seventy-fold. This enormous relative increase, which is an absolute increase of just 0.06 Gg CO_2 eq., is easily explained by the inclusion of end-of-life emissions, which – due to the very low lifetime EF of domestic refrigeration – constitute 93% of total domestic refrigeration emissions.

4.8.2 Consumption of SF6

Overview

Sulphur hexafluoride (SF_6) is used as insulation gas in gas insulated switchgear (GIS) and circuit breakers. The number of SF_6 users in Iceland is small. The bulk of SF6 used in Iceland is used by Landsnet LLC which operates Iceland´s electricity transmission system. A number of energy intensive plants, like aluminium smelters and the aluminium foil producer have their own high voltage gear using SF_6.

Methodology

SF_6 nameplate capacity development data as well as SF_6 quantities lost due to leakage were obtained from the above mentioned stakeholders. The data regarding leakage consisted of measured quantities as well as calculated ones. Measurements consisted mainly of weighing amounts used to refill or replace equipment after incidents. Quantities were calculated either by allocating periodical refilling amounts to the number of years since the last refilling or by assuming leakage percentages. This approach can best be described as a hybrid of GPG Tiers 2b and 3C.

Emissions

SF_6 emissions amounted to 131 kg in 2011 which is tantamount to 3.1 Gg CO_2 eq. or less than 0.1% of Iceland´s total GHG emissions in 2011. Emissions increased by 172% since 1990. However, this increase is less than proportional compared to the net increase in SF_6 nameplate capacity since 1990. Figure 4.8 shows both nameplate capacity development and emissions between 1990 and 2011. The spike in 2010 is caused by two unrelated incidents during which switchgear was destroyed and SF_6 emitted.

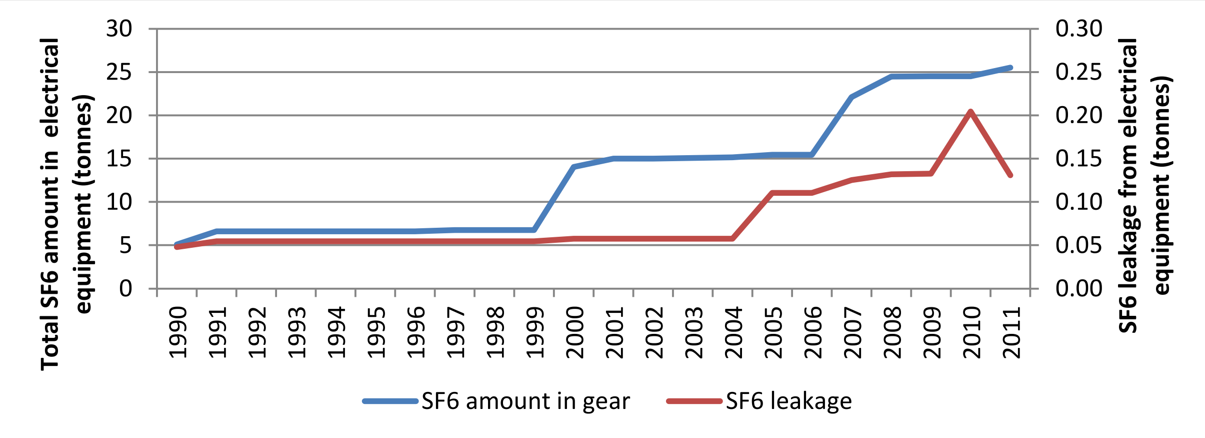

Figure 4.8. Total SF_6 amounts contained in and SF_6 leakage from electrical equipment (tonnes).

Uncertainty

Data regarding SF_6 nameplate capacity development during the last years is deemed to be accurate but deemed to be less accurate for the 1990s. The same holds true for emission estimates from the 1990s. Another source of uncertainty is a possible time lag between emissions and serving, i.e. that emissions detected by inspections performed less frequently than annual happened years ago. Monitoring devices, however, have greatly improved during the last years and the amounts in equipment and leaking from equipment are measured annually and known with good accuracy today. Uncertainty is divided into activity data uncertainty (measured amounts) and emission factor uncertainty (calculated amounts). By integrating the accuracy differences between more and less recent years AD uncertainty is estimated at 20% and EF uncertainty at 50% (expert judgement).

Recalculations

The activity data for SF_6 emissions from electrical equipment was reviewed and it was found that it only contained SF_6 amounts contained in the Icelandic electricity transmission system administered by Landsnet LLC. A number of energy intensive plants like aluminium smelters and the aluminium foil producer, have their own high voltage gear that uses SF_6however. These amounts were included as activity data and information on reported leakage from these new sources were included in emission estimates.

Methodology was moved from Tier 1 to Tier 2 methodology with consequences for emission factors used. In combination these changes to AD and EF resulted in a slightly lower estimate for SF_6 emissions from electrical equipment in 2010 (-1.2%).

5 Solvent and Other Product Use

5.1 Overview

This chapter describes non-methane volatile organic compounds (NMVOC) emissions from solvents and N_2O emissions from other product use in Iceland. NMVOC are not considered direct greenhouse gases but once they are emitted, they will oxidize to CO_2 in the atmosphere over a period of time. They are therefore considered as indirect greenhouse gases. Also, NMVOCs act as precursors to the formation of ozone. When volatile chemicals are exposed to air, emissions are produced through evaporation of the chemicals. The use of solvents and other organic compounds in industrial processes and households is an important source of NMVOC evaporation.

N_2O in Iceland is almost exclusively used as anaesthetic and analgesic in medical applications. Minor uses of N_2O in Iceland comprise its use in fire extinguishers and as fuel oxidant in auto racing.

In 1990 emissions from solvent and other product use had been 9.1 Gg CO_2 equivalents. Emissions decreased by 30% between 1990 and 2011 and were 6.3 Gg CO_2 equivalents in 2010 accounting for roughly 0.1% of the total greenhouse gas emissions of Iceland in 2010.

5.1.1 Methodology

NMVOC emissions are estimated according to the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009). In this chapter, sources of NMVOC are divided into subcategories using the classification of the EMEP guidebook. The nomenclatures of both EMEP guidebook and Common Reporting Format are shown in Table 5.1 along with the respective “Selected nomenclature for sources of air pollution“ (SNAP). N_2O emissions were estimated using the 2006 GL.

Table 5.1. Subcategories in the sector Solvents and other product use with their respective codes in CRF, EMEP, and SNAP.

Solvent and other product use	CRF	EMEP	SNAP	In this chapter
Paint application	3A	3A	0601	5.2
Degreasing and dry cleaning	3B	3B	0602	5.3
Chemical Products, manufacturing and processing	3C	3C	0603	5.4
Other	3D			
1. Use of N_2O for anaesthesia	3D.1			5.6
2. Fire extinguishers	3D.2			5.6
3. N_2O from aerosol cans	3D.3			5.6
4. Other use of N_2O	3D.4			5.6
5. Other NMVOC emissions from printing, other domestic use, other product use (preservation of wood and tobacco)	3D.5	3D	0604	5.5

5.1.2 *Key source analysis*

The key source analysis performed for 2011 has revealed that the sector Solvent and other product use is neither a key source category in level nor in trend. This is shown in Table 1.1.

5.1.3 *Completeness*

Table 5.2 shows the completeness of the sector. All greenhouse gas source categories have been estimated in this submission with the exception of N_2O from aerosol cans, which does not occur in Iceland.

Table 5.2. Solvent and other product use – completeness (E: estimated, NA: not applicable, NO: not occurring)

	CO_2	NMVOC	N_2O
Solvent and other product use			
Paint application	E	E	NA
Degreasing and dry cleaning	E	E	NA
Chemical Products, manufacturing and processing	E	E	NA
Other			
1. Use of N_2O for anaesthesia	NA	NA	E
2. Fire extinguishers	NA	NA	E
3. N_2O from aerosol cans	NA	NA	NO
4. Other use of N_2O	NA	NA	E
5. Other NMVOC emissions from printing, other domestic use, other product use (preservation of wood and tobacco)	E	E	NA

5.1.4 Source Specific QA/QC Procedures

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

5.2 Paint application

5.2.1 Methodology, activity data and emission factors

The greenhouse gas source categories Paint application, Degreasing, and Other NMVOC emissions from printing and other product use have in common that their activity data consists of data about imported goods and substances. This data was received from Statistics Iceland. Table 5.3 shows all customs codes used in the respective chapters. The customs codes stem from the newest customs code register, published online in January 2012 (http://tollur.is/upload/files/Tollskr%C3%A1%202012%20-%20web.pdf, Icelandic directorate of customs, 2012).

Table 5.3. Customs codes from the Icelandic directorate of customs (Icelandic directorate of customs, 2012)

Activity	Customs chapter	Sub-chapter	Extensions
Paint application	32	5	0
Paint application	32	8	All sub numbers except for 1003 (wood preservatives)
Paint application	32	10	All sub numbers
Paint application	32	11	0
Paint application	32	12	9001, 9009
Paint application	32	13	All sub numbers
Paint application	32	14	1001-1003
Paint application	38	14	10
Degreasing	27	7	3000
Degreasing	29	2	4100, 4200, 4300, 4400
Degreasing	29	3	1200, 1901, 2200, 2300
Degreasing	38	14	0021, 0029, 0090
Printing	32	12	1000
Printing	32	15	All sub numbers
Wood preservation	32	8	1003
Wood preservation	27	7	9100
Tobacco	24	1	All sub numbers
Tobacco	24	2	All sub numbers
Tobacco	24	3	All sub numbers except for 9109 (snuff)

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

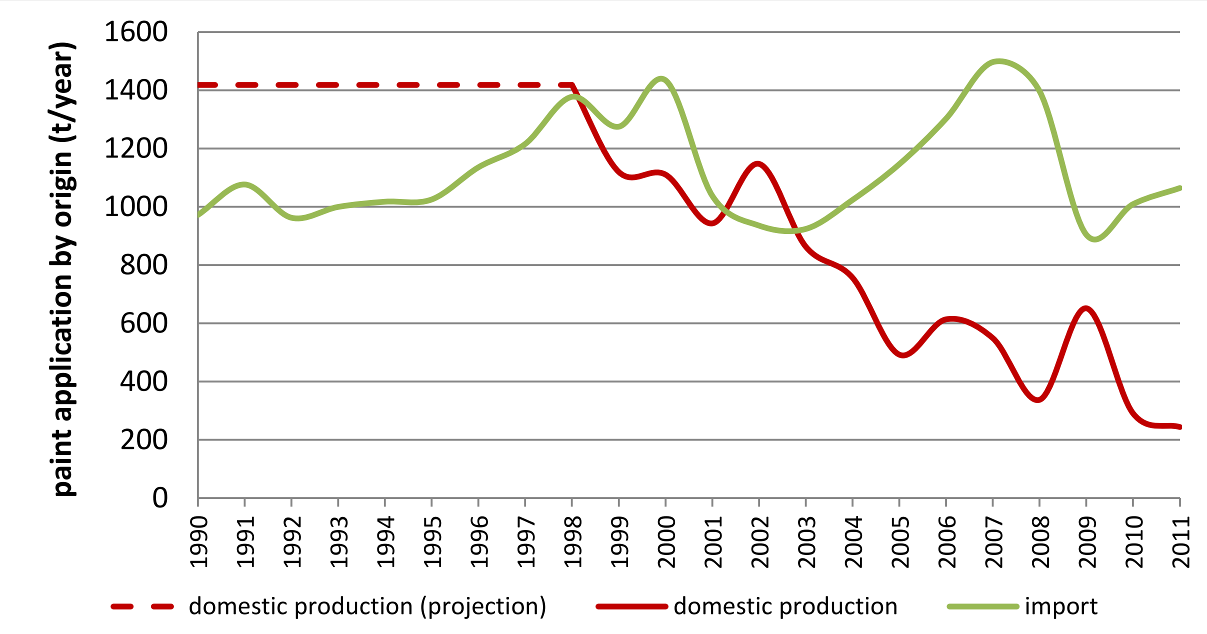

Figure 5.1. Amounts of solvent based paints imported and produced domestically

5.3 Degreasing and dry cleaning

5.3.1 Methodology, activity data and emissions

The EMEP guidebook provides a Tier 1 emission factor for degreasing based on amounts of cleaning products used. There is data on the amount of cleaning products imported provided by Statistics Iceland. Activity data consisted of the chemicals listed by the EMEP guidebook: methylene chloride (MC), tetrachloroethylene (PER), trichloroethylene (TRI) and xylenes (XYL). In Iceland, though, PER is mainly used for dry cleaning (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported PER was allocated to degreasing. Emissions from dry cleaning are estimated without using data on solvents used (see below). The use of PER in dry cleaning, though, is implicitly contained in the method. In Iceland, Xylenes are mainly used in paint production (expert judgement). In order to estimate emissions from degreasing more correctly without underestimating them, only half of the imported xylenes were allocated to degreasing. Emissions from paint production are estimated without using data on solvents used (see chapter 5.4.1) but xylene use is implicitly contained in the method. In addition to the solvents mentioned above, 1,1,1-trichloroethane (TCA), now banned by the Montreal

Protocol, is added for the time period during which it was imported and used. Another category included is paint and varnish removers. The amount of imported solvents for degreasing was multiplied with the NMVOC Tier 1 emission factor for degreasing: 460 g/kg cleaning product.

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

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

Where:

$E_{NMVOC}(t)$ = emissions of NMVOC in year t, kg

Population (t) = population in year t

0.3 = amount of textiles treated inhabitant/year, kg

177 = g NMVOC emissions/kg textile treated

0.89 = abatement efficiency of closed circuit PER machines

5.4 Chemical products, manufacturing and processing

5.4.1 Methodology, activity data and emissions

The only activity identified for the subcategory chemical products, manufacture and processing is manufacture of paints. NMVOC emissions from asphalt blowing, included in the EMEP guidebook under chemical products, are covered in the industry sector (NO in Iceland). NMVOC emissions from the manufacture of paints were calculated using the EMEP guidebook Tier 2 emission factor of 11 g/kg product. The activity data consists of the amount of paint produced domestically as discussed above in chapter 5.2.1.

5.5 Other NMVOC emissions

5.5.1 Methodology, activity data and emissions

Printing

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

Other domestic use

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

Other product use

Emissions from wood preservation were calculated using the EMEP guidebook Tier 2 emission factors for creosote preservative type (110 g/kg creosote) and organic solvent borne preservative (900 g/kg preservative). Import data on both wood preservatives was received from Statistics Iceland (Statistics Iceland, 2012).

NMVOC emissions from tobacco combustion were calculated using the EMEP guidebook Tier 2 emission factors for tobacco combustion of 3.5 g/tonne tobacco. Activity data consisted of all smoking tobacco imported and was provided by Statistics Iceland (Statistics Iceland, 2012).

5.6 N_2O from product uses

5.6.1 Methodology, activity data and emissions

N_2O emissions from product uses were calculated using the 2006 guidelines. Activity data stems from import and sales statistics from the two importers of N_2O to Iceland and is therefore confidential. It is assumed that all N_2O is used within 12 months from import/sale. Therefore emissions were calculated using equation 8.24 of the IPPU chapter of the 2006 guidelines, which assumes that half of the N_2O sold in year t are emitted in the same year and half of them in the year afterwards.

Equation 8.24

$$E_{N2O}(t) = \Sigma_i \{ [0.5 \bullet A_i(t) + 0.5 \bullet A_i(t-1)] \bullet EF_i \}$$

Where:

$E_{N2O}(t)$ = emissions of N_2O in year t, tonnes

A_i (t) = total quantity of N_2O supplied in year t for application type i, tonnes

A_i (t-1) = total quantity of N_2O supplied in year t-1 for application type i, tonnes

EF_i = emission factor for application type i, fraction

The 2006 GL recommend an emission factor of 1 for medical use of N_2O. This emission factor is also used for other N_2O uses. Around 95% of all N_2O imported is used for medical purposes.

Total emissions from N_2O use decreased from 19 tonnes N_2O in 1990 to 11 tonnes N_2O in 2010 or by 43%.

5.7 Emissions

Figure 5.2 shows NMVOC emissions from solvents and other product use from 1990-2010. NMVOC emissions were around one Gg from 1990 to 1995. Between 1996 and 2008 emissions oscillated between 1.1 and 1.3 Gg. The decrease of emissions during the last two years is mainly due to decreasing emissions from paint application, printing and organic wood preservatives.

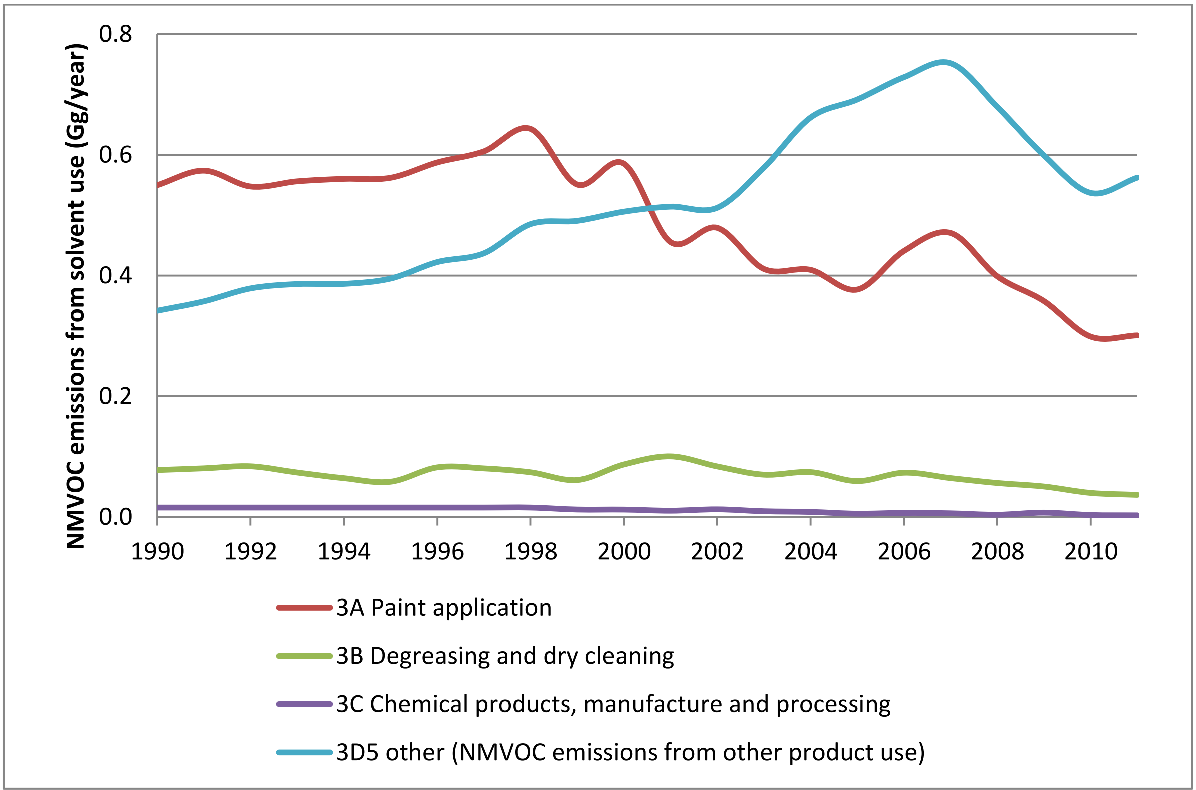

Figure 5.2. NMVOC emissions from solvent and other product use (Gg/year) from 1990-2010.

NMVOC emissions will oxidize to CO_2 in the atmosphere over a period of time. This conversion has been estimated with the following equation:

Emissions from NMVOCs in CO_2-equivalents

$$CO_2 \text{ equivalents} = 0.85 \bullet NMVOC_t \bullet 44/12$$

Where:

0.85 = Carbon content fraction of NMVOC

$NMVOC_t$ = Total NMVOC emissions in the year t

44/12 = Conversion factor

The addition of thus transformed NMVOC emissions and N_2O emissions from product use result in total emissions for solvent and other product use reported in chapter 5.1.

5.8 Uncertainties

NMVOC emissions along with respective uncertainty estimates were calculated for nine subcategories. Subsector AD and EF uncertainties were combined by multiplication using equation 6.4 from page 6.12 of the GPG. The main source for EF uncertainties were uncertainties and value ranges given in the EMEP GB. The combined subsector uncertainties were then combined into one value due to the relative insignificance of CO_2 emissions from this sector. Combination of uncertainties was achieved by using equation 6.3 from the GPG (page 6.12) using 2011 emissions as uncertain quantities. Combined AD uncertainty for the sector was 60%, combined EF uncertainty 613%. This resulted in 616% total uncertainty for CO_2 emission from the sector. The high uncertainty stems mainly from high EF uncertainties for a number of subsectors such as Degreasing (EF uncertainty = 2200%) and Printing (EF uncertainty = 1567%). Table 5.4 shows the uncertainties for the subsectors and the respective references.

Table 5.4. Subsector AD, EF, and combined uncertainties for CO_2 emissions from solvent use.

Subsector	AD uncertainty	EF uncertainty
Paint application	100[a]	130[b]
Degreasing	200[a]	2200[b]
Dry cleaning	1000[b]	95[b]
Chemical products	20[a]	9900[b]
Printing	50[a]	1567[b]
Other domestic use	5[a]	200[b]
Other product use: wood preservation, creosote	100[a]	115[b]
Other product use: wood preservation, organic solvent borne preservative	100[a]	128[b]
Other product use: tobacco	50[a]	149[b]

A = expert judgement; B = EMEP GB

The applied 2006 GL methodology accounts for a time lag between N_2O sale and its application. Activity data used in the emission inventory did not consist of sales data but of import data. Therefore the time lag might be greater than the 12 months the methodology accounts for. Therefore AD uncertainty is estimated to be +- 20% accurate in spite of accurate data on imports (expert judgement). An EF uncertainty of 5% is estimated in compliance with the value used in Denmark´s NIR (Nielsen et al., 2012). Combined uncertainty for N_2O emissions from other product use is therefore estimated to be 21%.

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

Total methane emissions from agriculture amounted to 12.2 Gg in 2011; total nitrous oxide emissions to 1.2 Gg. Thus combined CH_4 and N_2O emissions amounted to 641 Gg CO_2 eq. in 2011. Aggregated agriculture emissions were 707 Gg CO_2 eq. in 1990. The 9% decrease is mainly due to a decrease in sheep livestock population, reducing methane emissions from enteric fermentation and reduced fertilizer application reducing N_2O emissions from agricultural soils. 88% of CH_4 emissions were caused by enteric fermentation, the rest by manure management. 89% of N_2O emissions were caused by agricultural soils, the rest by manure management, i.e. during storage of manure.

6.1.1 Methodology

The calculation of greenhouse gas emissions from agriculture is based on the methodologies suggested by the IPCC Good Practice Guidance (IPCC, 2000). In three cases default values were taken from the 2006 IPCC Guidelines (IPCC, 2006). These exceptions concern the manure management methane emission factor for fur-bearing animals, the methane correction factor (MCF) for manure management systems, and default values for nitrogen excretion rate for animal species. The default for fur-bearing animals is non-existent in the GPG and the 1996 IPCC Guidelines and was taken from the 2006 guidelines for completeness' sake. MCF and nitrogen excretion defaults from the 2006 Guidelines better suit Icelandic circumstances and were therefore used. This will be discussed further in the respective chapters, 6.4.1 and 6.5.1.

The methodology for calculating methane emissions of cattle and sheep from enteric fermentation and manure management is based on the enhanced livestock population characterisation and therefore in accordance with tier 2 methodology. Tier 1 methodology is used to calculate methane emissions from enteric fermentation and manure management of other livestock. The methodology for calculating N_2O emissions from agricultural soils is in accordance with the Tier 1a method of the GPG. The sub-source N in crop residue returned to soils, however, was calculated using the Tier 1b method. Indirect N_2O emissions from nitrogen used in agriculture were calculated using the Tier 1a method.

6.1.2 *Key source analysis*

The key source analysis performed for 2011 (Table 1.1) revealed the following greenhouse gas source categories from the agriculture sector to be key sources in terms of total level and/or trend:

- Emissions from Enteric Fermentation, Cattle – CH_4 (4A1)
  - This is a key source in level (1990 and 2011)
- Emissions from Enteric Fermentation, Sheep – CH_4 (4A3)
  - This is a key source in level (1990 and 2011) and trend
- Emissions from Manure Management – N_2O (4B)
  - This is a key source in level (1990 and 2011)
- Direct Emissions from Agricultural Soils – N_2O (4D1)
  - This is a key source in level (1990 and 2011) and trend
- Pasture, Range, and Paddock Manure – N_2O (4D2)
  - This is a key source in level (1990 and 2011)
- Indirect Emissions from Agricultural Soils – N_2O (4D3)
  - This is a key source in level (1990 and 2011)

6.1.3 *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, NO: not occurring).

Sources	CO_2	CH_4	N_2O
Enteric Fermentation (4A)	NA	E	NA
Manure Management (4B)	NA	E	E
Rice Cultivation (4C)	Not Occurring		
Agricultural Soils (4D)			
1. Direct Emissions	NA	NA	E
2. Animal Production	NA	NA	E
3. Indirect Emissions	NA	NA	E
4. Other	Not Occurring		
Prescribed burning of Savannas (4E)	Not Occurring		
Field burning of Agricultural Residues (4F)	Not Occurring		
Other (4G)	Not Occurring		

6.2 Activity data

6.2.1 *Animal population data*

The Icelandic Food and Veterinary Authority (IFVA) conducts an annual livestock census. For the census, farmers count their livestock once a year in November and send the numbers to the IFVA. Consultants from local municipalities visit each farm during March of the following year and correct the numbers from the farmers in case of discrepancies. The IFVA reports the census to Statistics Iceland which publishes them.

This methodology provides greenhouse gas inventories which need information on livestock throughout the year with one problem: young animals that live less than one year and are slaughtered at the time of the census are not accounted for (lambs, piglets, kids, a portion of foals, and chickens). The population of lambs was calculated with information on infertility rates, single, double, and triple birth fractions for both mature ewes and animals for replacement, i.e. one year old ewes (Farmers Association of Iceland, written information, 2012). Number of piglets was calculated with data on piglets per sow and year (Farmers Association of Iceland, written information, 2012). Number of kids was calculated with information on birth rates received from Iceland´s biggest goat farmer (Þorvaldsdóttir, oral information, 2012). Numbers of foals missing in the census as well as hen, duck and turkey chickens were added with information received from the Association of slaughter permit holders and poultry slaughterhouses. Numbers for young animals with a live span of less than one year were weighed with the respective animal ages at slaughter:

- Lambs: 4.5 months
- Piglets: 5.9 months (1990) – 4.5 months (2010)
- Foals: 5 months
- Kids: 5 months
- Chickens (hens): 1.1 months
- Chickens (ducks): 1.7 months
- Chickens (turkeys): 2.6 months

As a result, the numbers of several animal species are higher in the NIR than they are in the national census. While differences are small for horses (2% in 2011), they are considerably higher for sheep and poultry (56 and 117%, respectively). Number of swine, however, is eleven times higher in the NIR than in the national census. Table 6.2 shows animal populations for 1990, 2000 and 2011 for the census and NIR as well as percentage differences between both.

Table 6.2. Livestock population data from original national census and after adding data on animals with a life span of less than one year unaccounted for in census to it (NIR). All numbers in animal years, i.e. number of animals with a life span of less than one year were weighted with their age at slaughter.

	1990	1990	2000	2000	2011	2011
Livestock category	census	NIR	census	NIR	census	NIR
dairy cattle	32,249	32,249	27,066	27,066	25,661	25,661
other mature cattle	22,536	22,536	27,157	27,157	26,935	26,935
young cattle	20,118	20,118	17,912	17,912	20,177	20,177
cattle (total)	74,903	74,903	72,135	72,135	72,773	72,773
mature ewes	445,635	445,635	373,194	373,194	373,603	373,603
other mature sheep	13,277	13,277	12,091	12,091	11,639	11,639
animals for replacement	89,795	89,795	80,289	80,289	89,517	89,517
lambs (weighted)		313,108		263,716		266,707
sheep (total)	548,707	861,815	465,574	729,290	474,759	741,466
increase ((NIR-census)/census)		57%		57%		56%
sows	3,135	3,135	3,862	3,862	3,619	3,619
piglets (weighted)		26,510		28,405		40,109
total swine	3,135	29,645	3,862	32,267	3,619	43,728
% increase ((NIR-census)/census)		846%		735%		1108%
adult horses	49,464	49,464	51,728	51,728	55,092	55,092
young horses	15,803	15,803	17,113	17,113	16,678	16,678
foals (weighted for NIR)	6,763	8,600	4,828	6,789	6,507	8,173
total horses	72,030	73,867	73,669	75,630	78,277	79,943
% increase ((NIR-census)/census)		3%		3%		2%
goats	345	345	416	416	818	818
kids (weighted)		159		192		377
total goats	345	504	416	608	818	1,195
% increase ((NIR-census)/census)		46%		46%		46%
minks	42,804	42,804	36,593	36,593	40,225	40,225
foxes	4,974	4,974	4,132	4,132	1,639	1,639
rabbits	1,814	1,814	706	706	193	193
hens	214,975	214,975	193,097	193,097	221,167	221,167
broilers	291,190	291,190	91,515	91,515	47,572	47,572
pullets	24,020	24,020	63,039	63,039	98,272	98,272
chickens		139,095		184,202		422,716
total chickens	530,185	669,280	347,651	531,853	367,011	789,727
% increase ((NIR-census)/census)		26%		53%		115%
ducks/geese/turkeys	3,618	3,618	5,762	5,762	3,052	3,052
ducks/geese/turkeys: chickens (weighted)		1,659		7,645		9,156
total ducks/geese/turkeys	3,618	5,277	5,762	13,407	3,052	12,208
% increase ((NIR-census)/census)		46%		133%		300%

6.2.2 Livestock population characterization

Enhanced livestock population characterisation was applied to cattle and sheep and subsequently used in estimating methane emissions from enteric fermentation and manure management.

In accordance with the census there are five subcategories used for cattle in the livestock population characterisation: mature dairy cows, cows used for producing meat, heifers, steers used principally for producing meat, and young cattle. The subcategories “cows used for producing meat” and “heifers, and steers used principally for producing meat” were aggregated in the category “other mature cattle”. The subcategory steers used principally for producing meat was the most heterogeneous in the census since it contains all steers between one year of age and age at slaughter (around 27 months) as well as heifers between one year of age and insemination (around 18 months). The population data did not permit dividing this subcategory further. The share of females inside the category was estimated by assuming that there were as many cows as steers inside the subcategory, only for a shorter time (6 vs. 15 months). This results in a share of cows of 29%. The subcategory young cattle contained both male and female calves until one year of age. Fractions of male and female calves fluctuated slightly between years.

For sheep the subcategory lambs was added to the census data. The following four categories were used for the livestock population characterization: mature ewes, other mature sheep, animals for replacement and lambs.

Table 6.3 shows the equations used in calculating net energy needed for maintenance, activity, growth, lactation, wool production and pregnancy for cattle and sheep subcategories. Equation 4.9 was used to calculate the ratio of net energy available in the animals´ diets for maintenance to the digestible energy consumed and equation 4.10 from the GPG was used to calculate the ratio of net energy available in the animals´ diets for growth to the digestible energy consumed. Net energy needed and ratios of net energy available in diets to digestible energy consumed were subsequently used in equation 4.11 from the GPG to calculate gross energy intake for cattle and sheep subcategories.

Table 6.3. Overview of equations used to calculate gross energy intake in enhanced livestock population characterisation for cattle and sheep (NA: not applicable)

Subcategory	**Equations from the GPG, Net energy for maintenance, activity, growth, lactation, wool, and pregnancy**					
	maintenance	activity	growth	lactation	wool	preg-nancy
mature dairy cows	4.1	4.2	NA	4.5a	NA	4.8
cows used for producing	4.1	4.2	NA	4.5a	NA	4.8
heifers	4.1	4.2	4.3a	NA	NA	4.8
steers used principally for producing meat	4.1	4.2	4.3a	NA	NA	NA
young cattle	4.1	4.2	4.3a	NA	NA	NA
mature ewes	4.1	4.3	NA	4.5c	4.7	4.8
other mature sheep	4.1	4.3	NA	NA	4.7	NA
animals for replacement[1]	4.1	4.3	4.3b	NA	4.7	4.8
Lambs	4.1	4.3	4.3b	NA	4.7	NA

1: Animals for replacement are considered from their birth until they are one year of age, which is also when they give birth for the first time. Therefore net energy for pregnancy is calculated whereas net energy for lactation is not applicable.

Table 6.4 shows national parameters that were used to calculate gross energy intake for cattle in 2011. Not all parameters have been constant over the last two decades. The ones that have changed during that time period are listed with the range for the respective parameter (see: chapter 6.2.3).

Table 6.4. Animal performance data used in calculation of gross energy intake for cattle in 2010. Where time dependent data is used, the range of data is shown in brackets below the 2010 value (NA: Not applicable, NO: Not occurring).

	Mature dairy cows	**Cows for producing meat**	**Heifers**	**Steers for producing meat**	**Young cattle**
Weight (kg)	430	500	370	328	126
Months in stall	8.7 (9 - 8.7)	1	8.1	10.9[1]	12
Months on pasture	3.3 (3 – 3.3)	11	3.9	1.1	0
Mature body weight (kg)	430	500	430	515[2]	515[2]
Daily weight gain (kg)	NO	NO	0.5	0.53	0.5
Kg milk per day	14.9 (11.3 – 15)	5.5	NA	NA	NA
Fat content of milk (%)	4.2	4.2	NA	NA	NA
Digestible energy (% of gross energy)	78.72	78.72	78.72	65.77	78.72

1: Steers are not allowed outside. The young cows inside the category are grazing on pasture for 120 days. 2: average for cows and steers, not weighted.

Table 6.5 shows national parameters that were used to calculate gross energy intake for sheep in 2011.

Table 6.5. Animal performance data used in calculation of gross energy intake for sheep from 1990-2010 (no time dependent data). NA: Not applicable, NO: Not occurring

	Mature ewes	Other mature sheep	Animal for replacement	Lambs
weight (kg)	65	95	36	21
Months in stall	6.6	6.6	6.6	0
Months on flat pasture	2	2	2	1.1
Months on hilly pasture	3.4	3.4	3.4	3.4
Body weight at weaning (kg)	22	22	22	22
Body weight at 1 year or old or at slaughter (kg)	NA	NA	55	38
Birth weight (kg)	4	4	4	4
Single birth fraction	0.185[1]	NA	0.55[1]	NA
Double birth fraction	0.72[1]	NA	0.14[1]	NA
Triple birth fraction	0.06[1]	NA	NO	NA
Annual wool production (kg)	3	2.5	1.5	1.5
Digestible energy (in % of gross energy)	69	69	69	69

1: Difference between sum of birth fractions and one is due to infertility rates of 3.5% for mature ewes and 31% for animals for replacement.

Figure 6.1 shows the gross energy intake (GE) in MJ per day for all cattle and sheep subcategories. As of the 2013 submission only mature dairy cattle have time dependent values for GE (see: chapter 6.2.3). The GE of mature dairy cattle has increased from 166 MJ/day in 1990 to 192 MJ/day in 2011. This increase is owed in small part to increased activity, i.e. more days grazing on pasture) and in large part to the increase in average milk production from 4.1 t in 1990 to 5.4 t in 2011.

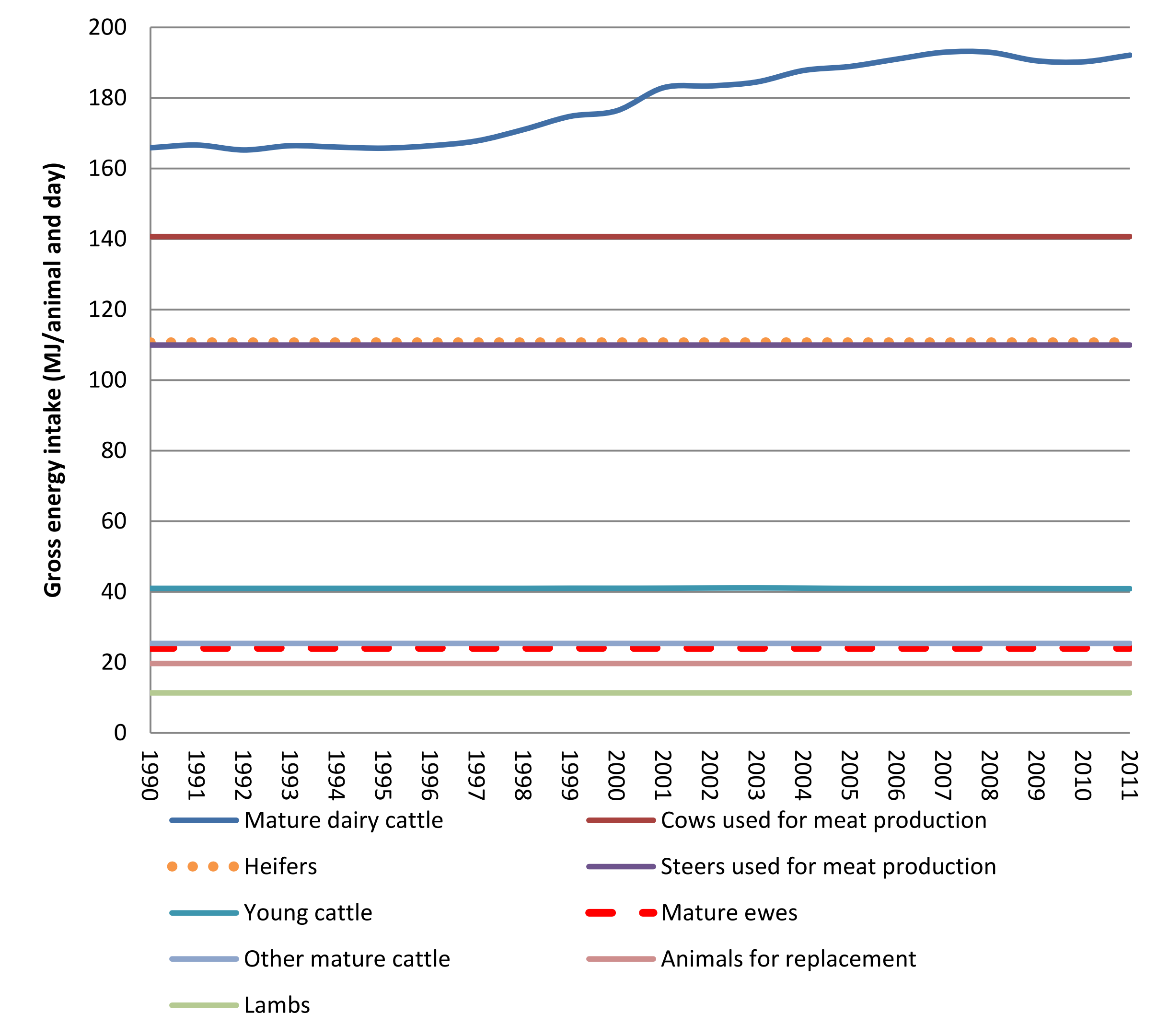

Figure 6.1. Gross energy intake (MJ/day) for cattle and sheep subcategories from 1990-2010.

6.2.3 Planned improvements

For the next submission it is planned to update digestible energy content of feed for both cattle and sheep in order to reflect changes in animal nutrition that have occurred since 1990.

6.3 CH_4 emissions from enteric fermentation in domestic livestock (4A)

The amount of enteric methane emitted by livestock is driven primarily by the number of animals, the type of digestive system, and the type and amount of feed consumed. Cattle and sheep are the largest sources of enteric methane emissions (IPCC, 2000).

6.3.1 Emission factors

Livestock population characterisation was used to calculate gross energy intake of cattle and sheep. The values for gross energy intake were used to calculate emission factors for methane emissions from enteric fermentation. To this end equation 4.14 from the GPG was applied:

Equation 4.14

Emission factor development

$$EF = (GE * Y_m * 365\ days/yr) / (55.65\ MJ/kg\ CH_4)$$

Where:

EF = emission factor, kg CH_4/head/yr

GE = gross energy intake, MJ/head/day

Y_m = methane conversion rate which is the fraction of gross energy in feed converted to methane

Gross energy intake is calculated in the livestock population characterisation. Methane conversion rate depends on several interacting feed and animal factors; good feed usually means lower conversion rates. Default values from the GPG were applied (Table 6.6).

Table 6.6. Methane conversion rates for cattle and sheep (IPCC, 2000)

Category/subcategory	Cattle	Mature sheep	Lambs (<1 year old)
Y_m	0.06	0.07	0.05

For pseudo-ruminant and mono-gastric animal species methane emission factors were taken from the 1996 Guidelines. The 1996 GL do not contain default emission factors for poultry and fur animals. Therefore default values from the Norwegian NIR (2011) were used for poultry and fur animals.

6.3.2 Emissions

Methane emissions from enteric fermentation in domestic livestock are calculated by multiplying emission factors per head for the specific livestock category with respective population sizes and subsequent aggregation of emissions of all categories.

There is only one livestock subcategory that has a gross energy intake that varies over time and as a result a fluctuating emission factors: mature dairy cattle (mainly due to the increase in milk production during the last two decades). Therefore the fluctuations in methane emissions from enteric fermentation for all other livestock categories shown in Table 6.7 are solely based on fluctuations in population size. The population size of mature dairy cattle has decreased by 20% between 1990 and 2011. Methane emissions, however, have only decreased by 8% from 2.1 Gg to 1.9 Gg during the same period due to the increase in the emission factor associated with the increase in milk production. The livestock category emitting most methane from enteric fermentation is mature ewes. Due to a proportionate decrease of population size, emissions from mature ewes decreased by 16% between 1990 and 2011 (from 4.9 to 4.1 Gg). Similar decreases can be seen for other sheep subcategories.

The only non-ruminant livestock category with substantial methane emissions is horses. Emissions from horses increased from 1.33 Gg methane in 1990 to 1.44 Gg methane in 2011 due to an equal increase in population size.

The decrease in methane emissions from cattle and sheep caused total methane emissions from enteric fermentation in agricultural livestock to drop from 11.6 Gg in 1990 to 10.8 Gg in 2011, or by 6.9% (Table 6.7).

Table 6.7. Methane emissions from enteric fermentation from agricultural animals for years 1990, 1995, 2000, 2005 and 2008-2011 in t methane.

livestock category	1990	1995	2000	2005	2008	2009	2010	2011
mature dairy cattle	2,105	1,985	1,878	1,824	1,990	1,986	1,925	1,940
cows used for producing meat	0	41	53	75	89	87	93	91
heifers	199	557	277	293	301	298	299	285
steers used for producing meat	777	665	859	659	777	803	821	811
young cattle	324	224	289	292	311	322	330	324
mature ewes	4,919	4,109	4,119	3,978	3,990	4,042	4,132	4,124
other mature sheep	154	144	141	131	135	134	135	135
animals for replacement	578	475	517	537	546	591	603	576
lambs	1,160	968	977	950	954	973	995	988
swine	44	47	48	57	70	63	61	65
horses	1,332	1,447	1,364	1,382	1,436	1,424	1,422	1,442
goats	2	2	3	3	4	4	5	5
fur animals	5	4	4	4	3	4	4	4
poultry	13	7	11	15	15	15	14	16
total methane emissions	11,614	10,674	10,540	10,200	10,621	10,747	10,838	10,808
emission reduction (year-base year)/base year		-8.1%	-9.3%	-12.2%	-8.6%	-7.5%	-6.7%	-6,9%

6.3.3 Uncertainties

Uncertainties of CH_4 emission estimates for enteric fermentation were assessed separately for cattle, sheep and other livestock categories. Cattle and sheep AD uncertainties were calculated as combined uncertainties of livestock population and livestock characterisation. Cattle and sheep population data were deemed reliable and were therefore attributed with an uncertainty of +-10% (expert judgement). Livestock characterisation uncertainty was calculated by propagating uncertainties of net and digestible energies. A +-20% uncertainty was attributed to all net energies used in the calculation. Digestible energy was attributed with an uncertainty of +-20% for the relatively low values of all sheep subcategories and bulls used for meat production. The relatively high DE of all other cattle subcategories was attributed an uncertainty of +10/-20% (all expert judgement). Propagation of uncertainty throughout the calculation of gross energy led to AD uncertainties between 21 and 29% for cattle (mean weighted with 2011 emissions = 24.6%) and 27 and 30 % for sheep (weighted mean = 27.4%). According to the GPG (page 4.28), emission factor estimates for enteric fermentation using Tier 2 are likely to be in the order of +-20%. The combination of AD and

EF uncertainties for cattle and sheep were therefore estimated to be 32 and 34 %, respectively. These values are also shown in Annex II.

Enteric fermentation emission estimates for other animals were calculated using Tier 1 methodology. This entailed that AD uncertainty stemmed from livestock population data only. Livestock population estimates of other livestock categories were deemed to be slightly more uncertain than the ones of cattle and sheep (+-20%, expert judgement). This is mainly due to the fact that the population of e.g. poultry at the time of the census does not allow for as good an estimate of the mean annual population as the population of other livestock categories. The GPG estimates EF accuracy between +-30 and +-50 % (page 4.27). This submission used a value of +-40%. This resulted in a combined uncertainty for CH_4 emissions from other animals of +- 45%.

6.4 CH_4 emissions from manure management (4B)

Livestock manure is principally composed of organic material. When this organic material decomposes in an anaerobic environment, methanogenic bacteria produce methane. These conditions often occur when large numbers of animals are managed in confined areas, e.g. in dairy, swine and poultry farms, where manure is typically stored in large piles or disposed of in storage tanks (IPCC, 2000).

6.4.1 Emission factors

Emission factors for manure management were calculated for cattle and sheep using data compiled in the livestock population characterization. For all other livestock categories IPCC default values were used. They originate from the 1996 Guidelines except for the ones for rabbits and fur-bearing animals, for which the 1996 Guidelines do not contain default values. For completeness´ sake these defaults were taken from the 2006 Guidelines. In order to calculate emission factors from manure management, daily volatile secretion (VS) rates have to be calculated first. VS are calculated using gross energy intake per day calculated in the livestock population characterisation, national values for digestible energy of feed and IPCC default values for ash content of manure. Equation 4.16 from the GPG was used.

Equation 4.16

Volatile solid excretion rates

$$VS = GE * (1 \text{ kg-dm}/18.45 \text{ MJ}) * (1 – DE/100) * (1 – ASH/100)$$

Where:

VS = volatile solid excretion per day on a dry-matter weight basis, kg-dm/day

GE = Estimated daily average feed intake in MJ/day

DE = Digestible energy of the feed in percent

ASH = Ash content of the manure in percent

Volatile solid excretion per day is then used in equation 4.17 from the GPG to calculate emission factors for manure management.

Equation 4.17

Emission factor from manure management

$$EF_i = VS_i * 365\ days/year * B_{oi} * 0.67\ kg/m^3 * \Sigma(j)\ MCF_j * MS_{ij}$$

Where:

EF_i = annual emission factor for defined livestock population *i*, in kg

VS_i = daily VS excreted for an animal within defined population *i*, in kg

B_{oi} = maximum CH4 producing capacity for manure produced by an animal within defined population *i*, m^3/kg of VS

MCF_j = CH4 conversion factors for each manure management system *j*

MS_{ij} = fraction of animal species/category *i*'s manure handled using manure system *j*

Maximum methane producing capacity values are taken from the 1996 Guidelines. They are 0.17 m^3/kg VS for non-dairy cattle, 0.19 m^3/kg VS for sheep, and 0.24 m^3/kg VS for dairy cattle. Methane conversion factors (MCF) for the three manure management systems used in cattle and sheep farming, i.e. pasture/range/paddock, solid storage and liquid/slurry are taken from the 2006 Guidelines. The reasoning behind the use of the 2006 GL defaults is that the GPG default of 0.39 is judged to be too high for Icelandic circumstances with an average annual temperature of 4°C (expert judgement). The application of the 2006 GL defaults was made after consultation with the IPCC Technical Support Unit (Srivastava, written communication). The high MCF for liquid/slurry is also incompatible with its counterparts from the 1996 and 2006 guidelines. This is shown in Table 6.8.

Table 6.8. Methane correction factors (fractions) included in Good practice guidance, 1996 and 2006 Guidelines for different manure management systems.

		cattle	cattle	cattle	sheep
	Conditions	pasture/range	solid storage	liquid/ slurry	all manure manag. systems
1996 GL	cool climate	1%	1%	10%	1%
GPG	cool climate	1%	1%	39%	same as for cattle
2006 GL	Average annual temperature <10°C	1%	2%	10%[1] 17%[2]	same as for cattle

1: with natural crust cover. 2: without natural crust cover; MCF used for liquid/slurry

Manure management system fractions

The fractions of total manure managed in the different manure management systems impact not only CH_4 emissions from manure management but also N_2O emissions from manure management and, as a consequence, N_2O emissions from agricultural soils. The fractions used are based on expert judgement (Sveinsson, oral communication; Sveinbjörnsson, oral communication; Dýrmundsson, oral communication) and are assumed to be constant since 1990 except for mature dairy cattle. The average amount of time mature dairy cattle spend on pasture has increased from 90 to 100 days over the last 20 years. Heifers spend 120 days per year on pasture whereas cows used for meat production spend 11 months on grazing pastures. Young cattle and steers are housed all year round. All cattle manure, i.e. not spread on site by the animals themselves, is managed as liquid/slurry without natural crust cover. Sheep spend 5.5 months on pasture and range; this includes the whole live span of lambs. 65% of the manure managed is managed as solid storage, the remaining 35% as liquid/slurry (Table 6.9).

Table 6.9. Manure management system fractions for all livestock categories

	liquid/slurry	solid storage	pasture/ range/ paddock
mature dairy cattle	73%		27%
cows used for producing meat	8%		92%
heifers	67%		33%
steers used for producing meat	91%		9%
young cattle	100%		0%
mature ewes	19%	36%	45%
other mature sheep	19%	36%	45%
animals for replacement	19%	36%	45%
lambs			100%
goats		55%	45%
horses		14%	86%
young horses		14%	86%
foals			100%
sows	100%		
piglets	100%		
poultry, fur animals		100%	

Emission factors both calculated with volatile solid excretion rates, methane conversion factors, and manure management fractions as well as IPCC default values for other livestock categories than cattle and sheep were used to calculate methane emissions from manure management and are shown in Table 6.10.

Mature dairy cows and steers have the highest emission factors for methane from manure management. Although mature dairy cows have a roughly 60% higher gross energy intake (average from 1990-2010), their emission factors are very similar. This is caused by two things: all steer manure is managed and therefore multiplied with a higher MCF than the share of manure accumulated by mature dairy cattle during grazing on pasture. More importantly, their feed has a lower digestible energy content, which in turn increases volatile solid excretion.

Table 6.10. Emission factors values, range and origin used to calculate methane emissions from manure management.

livestock category	emission factor 2011	emission factor range 1990-2010	source
	(kg CH_4/head year)	(kg CH_4/head year)	
mature dairy cattle	15.09	13.38-15.26	LPS[1]
cows used for producing meat	1.33		LPS[1]
heifers	5.73		LPS[1]
steers used for producing meat	12.09		LPS[1]
young cattle	3.06	3.06-3.08	LPS[1]
mature ewes	0.77		LPS[1]
other mature sheep	0.81		LPS[1]
animals for replacement	0.63		LPS[1]
lambs	0.08		LPS[1]
swine	3.00		1996 GL
horses	1.40		1996 GL
goats	0.12		1996 GL
minks	0.68		2006 GL
foxes	0.68		2006 GL
rabbits	0.08		2006 GL
poultry	0.08		1996 GL

1: Livestock population characterisation

6.4.2 Emissions

As can be seen in Table 6.10 above, there are no emission factor fluctuations for most livestock categories and only minor fluctuations for the remaining cattle subcategories. This implies that fluctuations in methane emission estimates for all livestock subcategories except mature dairy cattle can be explained by fluctuations in population sizes. Three livestock categories alone are responsible for roughly two thirds of methane emissions from manure management: mature dairy cattle, steers used for producing meat and mature ewes. The high emission factor for mature dairy cattle and steers has already been addressed. Mature ewes have an emission factor that is roughly twenty times lower than the ones for dairy cattle and steers but have a much bigger population size. Other important livestock categories for methane emissions from manure management are young cattle, animals for replacement, swine, horses, and poultry.

Total emissions from manure management have been stable for the last five years and were 1.42 Gg methane in 2011, i.e. 2% lower than they were in 1990 (Table 6.11).

Table 6.11. Methane emissions from manure management in tons.

livestock category	1990	1995	2000	2005	2008	2009	2010	2011
mature dairy cattle	435	407	382	368	399	398	384	387
cows used for producing meat	0.0	1.1	1.4	2.0	2.3	2.3	2.4	2.4
heifers	26	73	36	39	40	39	39	37
steers used for producing meat	217	186	240	184	217	224	229	227
young cattle	62	43	55	56	59	61	63	62
mature ewes	341	285	286	276	277	281	287	286
other mature sheep	11	10	10	9	9	9	9	9
animals for replacement	56	46	50	52	53	57	59	56
lambs	25	21	21	21	21	21	22	22
swine	89	93	97	115	140	125	122	131
horses	103	112	106	107	111	111	110	112
goats	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
fur animals (minks and foxes)	32	26	28	25	23	27	25	28
rabbits	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
poultry	53	28	43	60	58	60	56	63
total methane from manure management	1,451	1,332	1,355	1,314	1,409	1,417	1,409	1,423
emission reduction (year-base year)/base year		-8.2%	-6.7%	-9.4%	-2.9%	-2.4%	-2.9%	-1.9%

6.4.3 Uncertainties

Uncertainties of CH_4 emission estimates for manure management were assessed separately for cattle, sheep and other livestock categories. Cattle and sheep AD uncertainty was calculated as combined uncertainty of livestock population and volatile solid excretion rate uncertainty. Cattle and sheep population data were deemed reliable and were therefore attributed with an uncertainty of +-10% (expert judgement). Uncertainty related to volatile solid excretion rates was calculated by propagating uncertainties throughout the calculation of VS: i.e. combination of gross energy intake uncertainty, feed digestibility uncertainty and ash content uncertainty (cf. chapter 6.3.3). VS uncertainties ranged between 47 and 75% for cattle and 50 and 56% for sheep. AD uncertainty category means were deducted by weighting means with 2011 emission estimates. The respective values for cattle and sheep were 64% and 54%, respectively. EF uncertainties were estimated by combining assumed uncertainties for maximum methane producing capacity and methane correction factor uncertainty. The latter was estimated to be higher (100%, expert judgement) than the former (30%, expert judgement).

Emissions from other animals were attributed with a livestock uncertainty of 20% and an EF uncertainty of 200% (both expert judgement).

The above mentioned AD and EF uncertainties were combined by weighting them with 2011 emission estimates. This was done in order not to unnecessarily fragment categories for key source and uncertainty analyses. Category AD uncertainty amounted to 51% and category EF uncertainty to 127% combining to a total uncertainty of 137% for methane emission estimates from manure management. These values are summarized in Annex II.

6.5 N_2O emissions from manure management

The nitrous oxide estimated in this section is the N_2O produced during the storage and treatment of manure before it is applied to land. The emission of N_2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment (IPCC, 2000). In the case of animals whose manure is unmanaged (i.e. animals grazing on pasture or grassland, animals that forage or are fed in paddocks, animals kept in pens around homes) the manure is not stored or treated but is deposited directly on land. The N_2O emissions generated by manure in the system pasture, range, and paddock occur directly and indirectly from the soil, and are therefore reported in chapters 6.6 and 6.7

6.5.1 Activity data

Equation 4.18 in the GPG lists the input variables (printed in bold and discussed below) necessary to estimate N_2O emissions from manure management. Note that all remaining formulae in this chapter report N_2O emissions in units of nitrogen. N_2O emissions are subsequently calculated by multiplying units of nitrogen with 44/28 (molar mass of N_2O divided by molar mass of N_2).

EQUATION 4.18

N_2O EMISSIONS FROM MANURE MANAGEMENT

$$(N_2O\text{-}N) = \Sigma_{(S)} \{[\Sigma_{(T)} (N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)})] \bullet EF_{(S)}\}$$

Where:

$(N_2O\text{-}N)$ = N_2O-N emissions from manure management in the country (kg N_2O-N/yr)

$N_{(T)}$ = Number of head of livestock species/category T in the country

$Nex_{(T)}$ = Annual average N excretion per head of species/category T in the country (kg N/animal/yr)

$MS_{(T,S)}$ = Fraction of total annual excretion for each livestock species/category T that is managed in manure management system S in the country

$EF_{(S)}$ = N_2O emission factor for manure management system S in the country (kg N_2O-N/kg N in manure management system S)

S = Manure management system

T = Species/category of livestock

Numbers for head of livestock species/category exist (with distinction between adult and young animals for all livestock categories with the exceptions of rabbits and fur animals). The manure management system fractions for cattle and sheep have been discussed in chapter 6.4.1. Two thirds of Icelandic horses are on pasture all year round. The remaining third spends around five months in stables, where manure is managed in solid storage. All swine manure is managed as liquid/slurry whereas the manure of fur animals and poultry is managed in solid storage. Manure management system fractions are assumed to be stable during the past twenty years and were summarized above in Table 6.9.

Average annual nitrogen excretion rates were calculated using 2006 GL default values (Table 6.12). The defaults relate to 1000 kg animal mass. This means that they account for two cows weighing 500 kg each or roughly 15 ewes weighing 65 kg each. The calculated default for dairy cattle was not used since national, time dependent values existed: Ketilsdóttir and Sveinsson (2010) measured the Annual N excretion rates for dairy cows. The resulting value of 94.8 kg N was applied to dairy cows from 2000-2010. Since the value is based on new measurements for dairy cows with an annual milk production in excess of 5000 kg, it was adjusted for the 1990s (average milk production of 4200 kg) by interpolating linearly between it and a national literature value of 72 kg (Óskarsson and Eggertsson, 1991).

Table 6.12. Nitrogen excretion rates (N_{ex})

livestock category	N_{ex} default (kg N/1000 kg animal mass/day)	animal weight (kg)	annual N excretion rates (kg N/animal year)
mature dairy cattle	0.48	430	75.3[1]
cows used for producing meat	0.33	500	60.2
heifers	0.33	370	44.5
steers used for producing meat	0.33	328	39.5
young cattle	0.33	126	15.2
mature ewes	0.85	65	20.2
other mature sheep	0.85	95	29.5
animals for replacement	0.85	36	11.1
lambs	0.85	21	6.5
sows	0.42	150	23.0
piglets	0.51	41	7.6
horses	0.26	375	35.6
young horses	0.26	175	16.6
foals	0.26	60	5.7
goats	1.28	44	20.3
minks			4.6
foxes			12.1
rabbits			8.1
hens	0.96	4	1.4
broilers	1.10	4	1.6
pullets	0.55	3	0.6
chickens	0.55	1	0.2
ducks/geese	0.83	4	1.2
turkeys	0.74	5	1.4

1: National, time dependent values ranging from 72 to 94.8 kg N were used instead.

6.5.2 Emission factors

Emission factors are taken from the GPG, table 4.12: 0.001 kg N_2O-N is emitted per kg nitrogen excreted when manure is managed as liquid slurry. 0.02 kg N_2O-N is emitted per kg nitrogen excreted when manure is managed in solid storage as well as when it is unmanaged, i.e. deposited directly on soils by livestock.

6.5.3 Emissions

N_2O emissions from the manure management systems liquid/slurry and solid storage amounted to 142 tonnes N_2O in 2011 and 168 tonnes in 1990. This was tantamount to a 16 tonne decrease in emissions of N_2O .

Emissions from liquid systems make up only a small part of total emissions from managed systems or only 6% of total emissions from manure management systems in 2011. This is because the emission factor is twenty times lower for liquid systems than for solid storage. The majority of emissions originated from the solid storage of sheep manure (71% in 2010, followed by solid storage of poultry manure (12%), horse manure (7%), and fur animal manure (5%). Figure 6.2 shows N_2O emissions from liquid systems and solid storage. It also includes emissions from manure deposited directly onto soils from farm animals. Although they are reported under emissions from agricultural soils in national totals, they are included here to show their magnitude in comparison to other emissions. In 2011 N_2O emissions from manure spread on pasture by livestock amounted to 271 tonnes or almost twice as much as aggregated emissions from liquid systems and solid storage. Emissions from sheep manure were 180 tonnes, emissions from horse manure were 62 tonnes, and emissions from cattle manure amounted to 29 tonnes N_2O.

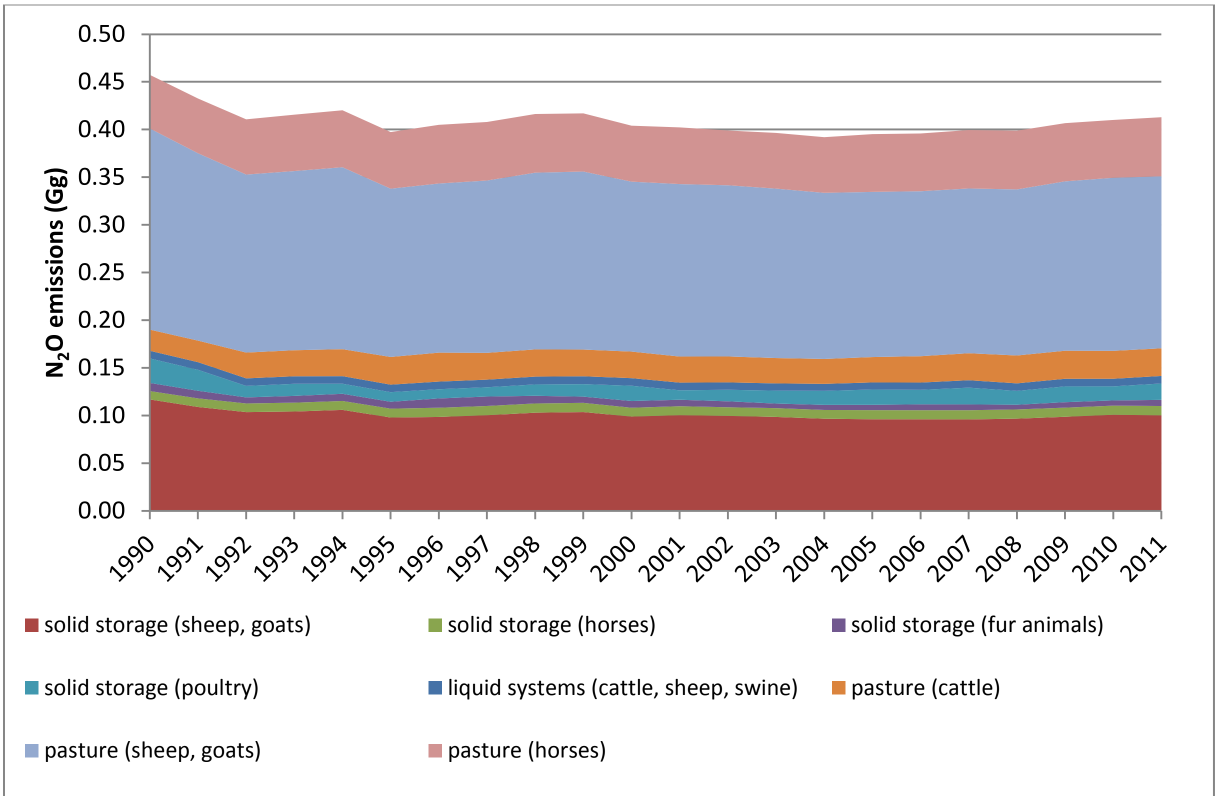

Figure 6.2. N_2O emissions from manure management in Gg N_2O.

6.5.4 Uncertainties

Uncertainty for N_2O emissions from manure management was estimated by combining cattle, sheep and other animal uncertainties. AD uncertainty was calculated as combined uncertainty of livestock population, nitrogen excretion and manure management system uncertainties. Livestock population uncertainties were 10 % for cattle and sheep and 20 % for all other animals (expert judgement). Nitrogen excretion rates were drawn from the 2006 GL which state their uncertainty as +-50% (page 10.66). Manure management system uncertainty is highest for sheep due to the variability in sheep manure management (25%) and less for other livestock categories (10%). These uncertainties were combined by multiplication for each of the three categories and then weighted by 2011 emission estimates, resulting in an AD uncertainty of 56%. Tables 4.12 and 4.13 in the 2006 GL attribute an EF uncertainty of 100% to N_2O emission factors from manure management. The weighted combined uncertainty for N_2O emissions from manure management was therefore estimated to be 115%.

Uncertainty estimates for emissions from animal production were calculated analogously and weighted with emissions from pasture, range, and paddock manure yielding a combined uncertainty of 115%.

6.5.5 *Planned improvements*

The nitrogen excretion rate for cattle and sheep will be recalculated using data on feed and crude protein intake developed in the Livestock population characterisation and default N retention rates to recalculate nitrogen intake. The AUI has carried out a study on manure management system fractions for sheep in Iceland. Its results will be included in the next submission.

6.6 Direct N_2O emissions from agricultural soils

Nitrous oxide (N_2O) is produced naturally in soils through the microbial processes of nitrification and denitrification. Agricultural activities like the return of crop residue, use of synthetic fertilizer and manure application add nitrogen to soils, increasing the amount of nitrogen (N) available for nitrification and denitrification, and ultimately the amount of N_2O emitted. The emissions of N_2O that result from anthropogenic N inputs occur through both a direct pathway (i.e. directly from the soils to which the N is added), and through two indirect pathways, i.e. through volatilisation as NH_3 and NO_x and subsequent redeposition and through leaching and runoff (IPCC, 2000). Direct N_2O emissions from agricultural soils are described here, indirect emissions in chapter 6.7.

6.6.1 *Activity data and emission factors*

Direct N_2O emissions from agricultural soils are calculated with equation 4.20 from the GPG. Of the five possible sources of input into soils four are applicable for Iceland:

- Synthetic fertilizer nitrogen
- Animal manure nitrogen used as fertilizer
- Nitrogen in crop residues returned to soils
- Cultivation of organic soils

EQUATION 4.20

DIRECT N_2O EMISSIONS FROM AGRICULTURAL SOILS (TIER 1a)

$$N_2O_{Direct}\text{-}N = [(F_{SN} + F_{AM} + F_{BN} + F_{CR}) \bullet EF_1] + (F_{OS} \bullet EF_2)$$

Where:

N_2O_{Direct} -N = Emission of N_2O in units of Nitrogen

F_{SN} = Annual amount of synthetic fertiliser nitrogen applied to soils adjusted to account for the amount that volatilises as NH_3 and NO_x

F_{AM} = Annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilises as NH_3 and NO_x

F_{BN} = Amount of nitrogen fixed by N-fixing crops cultivated annually

F_{CR} = Amount of nitrogen in crop residues returned to soils annually

F_{OS} = Area of organic soils cultivated annually

EF_1 = Emission factor for emissions from N inputs (kg N_2O-N/kg N input)

EF_2 = Emission factor for emissions from organic soil cultivation (kg N_2O-N/ha-yr)

Synthetic fertilizer nitrogen (F_{SN})

Activity data comes from the Icelandic Food and Veterinary Authority (IFVA) and consists of the amount of nitrogen contained in synthetic fertilizer applied to soils with the exception of the amount of fertilizer applied in forestry (Figure 6.3). The amount has to be adjusted for the amount that volatilizes as NH_3 and NO_x. The IPCC default for volatilization of synthetic fertilizer N is 0.1.

Animal manure nitrogen (F_{AM})

Animal manure nitrogen is calculated by multiplying Nitrogen excretion rates per head and year for livestock species/categories with the respective population sizes (see chapter: 6.5.2). The amounts have to be adjusted for N that volatilizes as NH_3 and NO_x. The IPCC default for volatilization of animal manure N is 0.2. The nitrogen amount from manure has to be further reduced by the amount deposited onto soils by grazing livestock, which is accounted for separately. Activity data development can be seen in Figure 6.3.

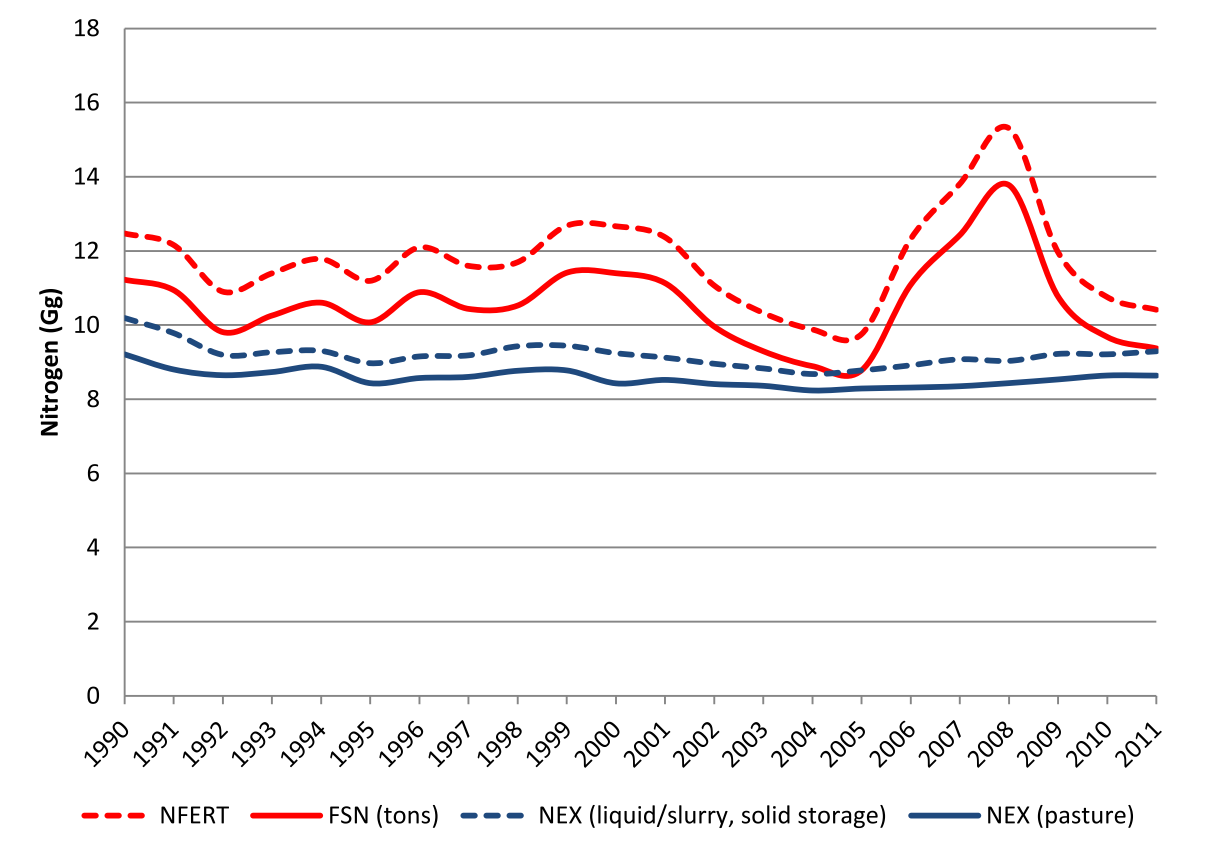

Figure 6.3. Amounts of nitrogen from synthetic fertilizer and animal manure application. Solid lines show nitrogen amounts adjusted for volatilization. Total N amounts are shown in dashed lines of same colour.

Nitrogen in crop residues returned to soils (FCR)

There are four crops cultivated in Iceland: potatoes, barley, beets and carrots. After harvest crop residues are returned to soils. The amounts of residues returned to soils are derived from crop production data. Statistics Iceland has production data for the four crops. The amount of residue per crop returned to soils is calculated using the Tier 1b method of the GPG:

Amount of produce * residue/crop product ratio * dry matter fraction * nitrogen fraction * (1 – fraction of residue used as fodder)

Residue/crop ratio, dry matter fraction and nitrogen fraction are IPCC default values. Dry matter fraction defaults, though, do not exist for potatoes and beet. By expert judgement, they are estimated to be 0.2 for both crops. No defaults exist for carrots. Therefore beet defaults are applied. It is estimated that 80% of barley residue is used as fodder. Crop produce amounts are shown in Figure 6.4.

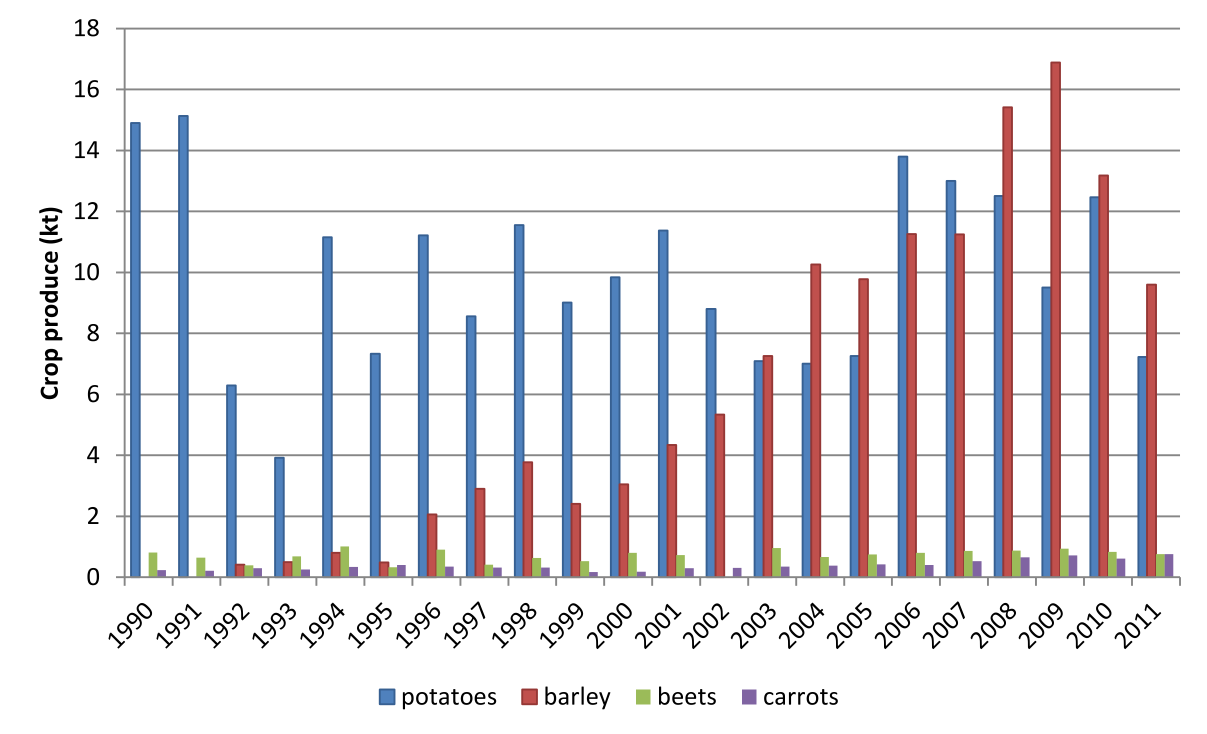

Figure 6.4. Crop produce in kilotonnes for 1990-2011

The amount of nitrogen in crop residues returned to soils was lowest in 1993, when it amounted to roughly 5 tonnes and highest in 2008 when it amounted to roughly 27 tonnes. It has to be noted, however, that there is a difference in scale between amounts of nitrogen in crop residues returned to soils and N amounts in synthetic fertilizer and animal manure applied to soils. Whereas the first amount ranges between 10 and 20 tonnes, the latter range from 5,000 – 15,000 tonnes annually.

Cultivation of organic soils

In response to a remark of the review of the Icelandic 2010 submission, the N_2O emissions from cultivated organic soils were included under the Agriculture sector. Data about the area of cultivation of organic soils, including histosols, histic andosols, and hydric andosols, is supplied by the Agricultural University of Iceland. The area estimate for cultivated organic soils in 1990 was 65 kha. This area has decreased steadily since then and was estimated to be less than 58 kha in 2011.

6.6.2 Emission factors

The common emission factor for F_{SN}, F_{AM}, and F_{CR} was the IPCC default value of 1.25% kg N_2O-N/kg N.

A country specific emission factor of 0.97 kg N_2O-N per ha was used as organic soil emission factor. It is based on measurements in a recent project where N_2O emissions were measured on drained organic soils. In this project, at total of 231 samples were taken from drained organic soils in every season over three years. The results have shown that the EF is higher for cultivated drained soils (0.97 kg N_2O-N per ha) than other drained soils (0.01 and 0.44 kg N_2O-N per ha) and much lower than the EF for tilled drained soils (8.36 kg N_2O-N per ha).

This research was conducted in Iceland over the period from 2006 to 2008 and is considered to be reliable. The results have not been published in peer viewed papers, yet, but publication is in preparation. Results are available in a project report to the Icelandic Research Council (Guðmundsson, 2009).

6.6.3 Emissions

The product of nitrogen amounts and respective emission factors was subsequently transformed into N_2O emissions by multiplying units of nitrogen with 44/28 (molar mass of N_2O divided by molar mass of N_2).

Direct emission from agricultural soils amounted to 418 tonnes N_2O in 2010, which meant a decrease of 13% in comparison to 1990 emissions. Drivers behind the decrease were decreasing amounts of synthetic fertilizer and animal manure applied to soils as well as the decrease in the total area of cultivated soils. 44% of 2010 emissions originated from synthetic fertilizer application, 35% from animal manure application and 21% from organic soils. The contribution of N in crop residues returned to soils is extremely low (0.1%). Annual fluctuations in emissions are mainly caused by the amount of fertilizer applied to soils (Figure 6.5).

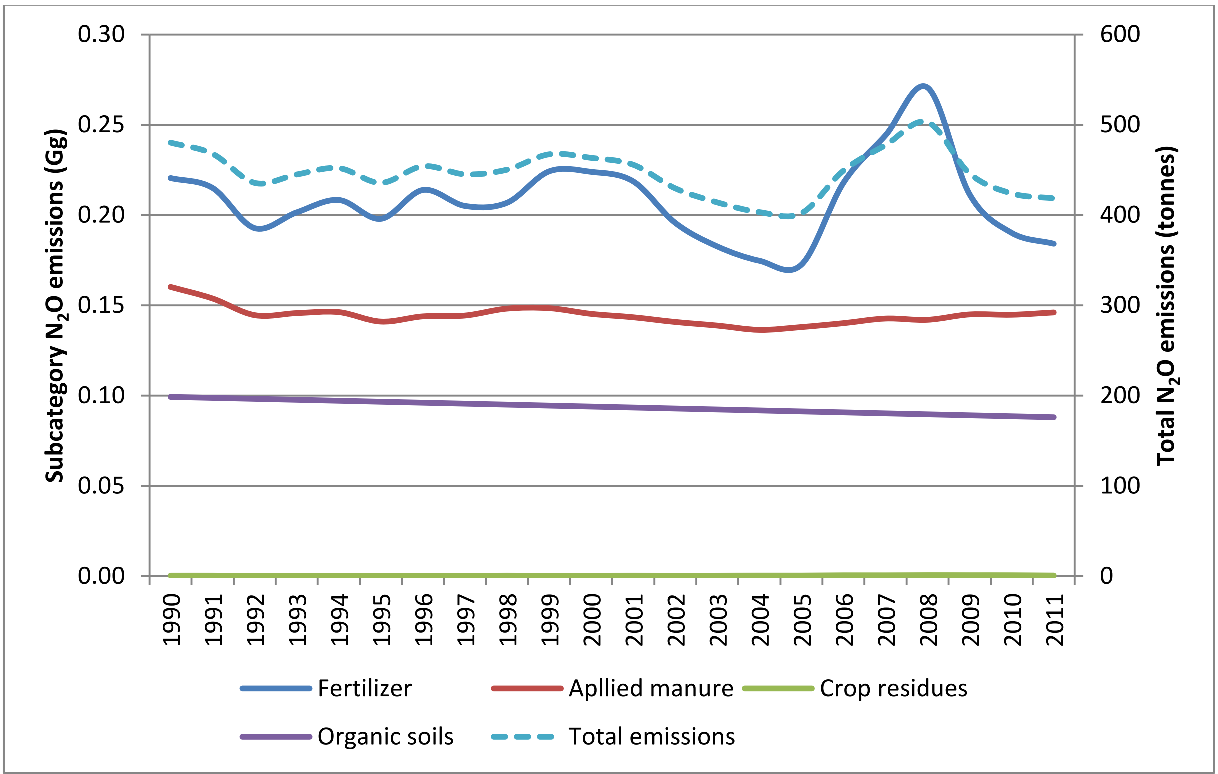

Figure 6.5. Direct N_2O emissions from soils (Gg).

6.6.4 Recalculations and improvements

In last year´s submission an error occurred while transcribing data received from the AUI. The area development of cultivated organic soils was transcribed backwards: 1990 values were put in as 2010 values and vice versa. This lead to a reported area increase when in reality area was decreasing. During the review of Iceland´s 2012 submission the error was detected and corrected.

The revision increased estimates of direct emissions from soils for all years before 2000 and decreased estimates for all years afterwards. For 2010 the difference amounted to approximately 11 tonnes N_2O or 2.5% of all direct N2O emissions from agricultural soils.

6.6.5 Uncertainties

Uncertainties from direct soil emissions were estimated for the category as a whole. To this end AD and EF uncertainties of fertilizer nitrogen, manure nitrogen, and area of organic soils cultivated annually were first weighted with respective 2011 emissions and then combined by multiplication in order to result in combined uncertainty estimates for the emission category. The amount of N in fertilizer applied was deemed to be known with an uncertainty of +-20% mainly stemming from possible differences between annual import and final application (expert judgement). The uncertainty in the amount of nitrogen in manure applied to soils was with higher (54%) as a result of multiplying NEX uncertainties (as described in chapter 6.5.4) with a livestock population uncertainty of 20%. The area of cultivated organic soils was attributed with an uncertainty of +-20% in accordance with area uncertainty estimates for cropland in LULUCF. Total AD uncertainty for direct N_2O emissions from soils weighted with 2011 emission estimates was therefore 32%.

AD uncertainty, however, is overshadowed by emission factor uncertainty related to nitrogen application to soils. According to the GPG does the best estimate of the 95% confidence interval range from one fifth to five times the EF of 1.25%, i.e. 500% uncertainty. Uncertainty for the country specific value for N_2O emissions from cultivated organic soils is 25%. EF uncertainty was weighted in the same way as AD uncertainty resulting in a value of 400%. Combination of AD and EF uncertainties for direct soil emissions yielded a value of 401%.

6.7 Indirect N_2O emissions from nitrogen used in agriculture

6.7.1 Activity data and emission factors

Indirect N_2O emissions originate from three sources:

- Volatilization of applied synthetic fertilizer and animal manure and subsequent atmospheric deposition
- Leaching and runoff of applied fertiliser and animal manure and
- Discharge of human sewage nitrogen into rivers or estuaries

The last source is covered in chapter 8.3. The first two sources are covered here.

N_2O from atmospheric deposition

Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NOx) and ammonium (NH_4) fertilises soils and surface waters, which results in enhanced biogenic N_2O format According to the 1996 guidelines, the amount of applied agricultural N that volatilizes and subsequently deposits on nearby soils is equal to the total amount of synthetic fertiliser nitrogen applied to soils plus the total amount of animal manure nitrogen excreted in the country multiplied by appropriate volatilisation factors (IPCC, 1996). That means that this emission source shares activity data with direct emissions from agricultural soils. Here, this includes manure deposited on pasture by grazing livestock. The amounts of nitrogen that were subtracted from total N in order to adjust for volatilization from fertilizer and animal manure application in chapter 6.6 "Direct emissions from agricultural soils" constitute activity data for N_2O from atmospheric deposition. That means that N amounts in fertilizer are multiplied with 0.1 and amounts in animal manure with 0.2 in order to calculate N_2O from atmospheric deposition. This is summarized in equation 4.31 of the GPG. The IPCC emission factor for estimating indirect emissions due to atmospheric deposition of N_2O is 0.01 kg N_2O-N/kg NH_4-N & NO_x-N deposited.

EQUATION 4.31

N_2O FROM ATMOSPHERIC DEPOSITION OF N (TIER 1a)

$$N_2O(G)\text{-}N = [(N_{FERT} \bullet Frac_{GASF}) + (\Sigma T(N_{(T)} \bullet Nex_{(T)}) \bullet Frac_{GASM})] \bullet 0.01$$

Where:

$N_2O(G)$ = N_2O produced from atmospheric deposition of N, kg N/yr

N_{FERT} = total amount of synthetic nitrogen fertiliser applied to soils, kg N/yr 20

$\Sigma T(N_{(T)} \bullet Nex_{(T)})$ = total amount of animal manure nitrogen excreted in a country, kg N/yr

$Frac_{GASF}$ = fraction of synthetic N fertiliser that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N input

$Frac_{GASM}$ = fraction of animal manure N that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N excreted

N_2O from leaching and runoff

A large proportion of nitrogen is lost from agricultural soils through leaching and runoff. This nitrogen enters groundwater, wetlands, rivers, and eventually the ocean, where it enhances biogenic production of N_2O (IPCC; 2000). To estimate the amount of applied N that leaches or runs off, amount of synthetic fertilizer and animal manure applied to soils (including manure deposited on pasture by grazing livestock) is multiplied by the fraction that is lost through leaching and runoff (GPG: 0.3). Indirect N_2O emissions from leaching and runoff are calculated by multiplying the resulting nitrogen amount with the GPG emission factor for estimating indirect emissions due to leaching and runoff of N_2O: 0.025 kg N_2O-N/kg N leached & runoff.

6.7.2 Emissions

The development of indirect N_2O emissions from 1990-2010 - after conversion from nitrogen to nitrous oxide - is shown in Figure 6.6. N_2O emissions amounted to 407 tonnes N_2O in 2010, which meant a 11% decrease from the 1990 value of 456 tonnes. The general downward trend in emissions was reversed from 2006 to 2008, when high amounts of synthetic fertilizer application caused an increase of indirect N_2O emissions from agricultural soils above the 1990 level.

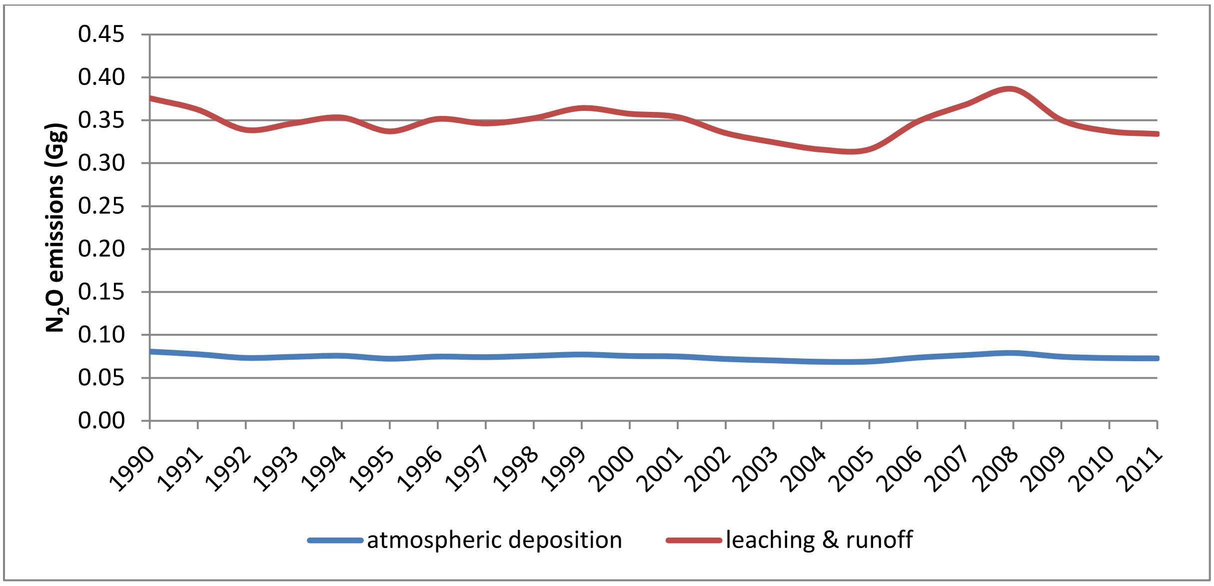

Figure 6.6. Indirect N_2O emissions from agricultural soils.

6.7.3 Uncertainties

Uncertainties from indirect soil emissions were estimated for the category as a whole. To this end AD and EF uncertainties of fertilizer nitrogen and manure nitrogen were first weighted with respective 2011 emissions and then combined by multiplication in order to result in combined uncertainty estimates for the emission category. AD uncertainty consists of AD the uncertainty regarding the amount of nitrogen in fertilizer and manure (cf. chapter 6.6.5) combined with uncertainty regarding the fraction of N that volatilizes, which is estimated by the GPG to be +-50% (p. 4.75). Combined weighted AD uncertainties of 67% are dwarfed by an order of magnitude uncertainty for the EF (GPG, page 4.75). Combined uncertainties are estimated to be 1002%.

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 forest and revegetation.

The CRF for LULUCF was prepared through UNFCCC CRF Reporter program (version 3.6.2). 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. The structure of information is mostly the same as in last submission, except for three new categories now reported for the first time. These categories are "Cropland converted to Forest land- Afforestation 1-50 years old", "Grassland converted to Forest Land-Afforestation natural birch forest 1-50 years old" and "Grassland remaining Grassland-Natural birch shrubland – recently expanded into Other Grassland". Beside that few categories were renamed both as response to the new categories and harmonizing between reporting categories. The subcategory "Natural birch forest" of "Forest land remaining Forest land" was changed to "Natural birch forest older than 50 years" and the category "Natural birch shrubland" of "Grassland remaining Grassland" was renamed to "Natural birch shrubland old". The subcategories of "5G-Other- Grassland Non-CO2 emission- (5II) Non CO2 emissions from drainage of soils and wetlands – Organic soils" were renamed to match the Grassland subcategories the emission is related to. Thus "Grassland former Cropland remaining Grassland" becomes "Cropland abandoned for more than 20 years" and "Grassland former wetland remaining wetland" becomes "Wetland drained for more than 20 years". Time series from previous submissions have been extended to the inventory year.

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 as in last year submission the area estimate for the all land use categories is based on this database except where more precise estimates are available.

Due to limitations of present version of UNFCCC CRF-Reporter the Non-CO_2 emissions of Grassland are still reported under 5.G- Other.

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 (see QC/QA chapters of each category). 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 is 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.

The map layers of Natural birch forest and Natural birch shrubland have been revised and the compilation process of the land use map as described in chapter 7.3.6 and in (Gudmundsson et al. 2013) repeated applying these revised map layers. The new compilation resulted in revised area estimate for many categories.

The processing of land use data is described below.

The emissions reported for the LULUCF sector in 2011 equals 746.23 Gg CO_2-equivalents compared to 733.80 Gg CO_2-equivalents in 2010. In this year's submission the estimated LULUCF emission for 2010 is 795.75 Gg CO_2-equivalents reflecting recalculation effects. The revision of emission and removal involves several previous reported categories and also estimates are provided for new categories hereto not estimated.

7.2 Land use practices and consequences

The dominant land use through the ages in Iceland 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 19th 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 cultivation 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.

On-going 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 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 of the land was 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 often 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 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 led 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.

The natural birch woodland has been mapped in two surveys, first in 1972-1975 and again in 1987-1991. 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). IFR started a remapping of the natural birch woodland in 2010 that are planned to be finished in 2014. These new maps are used for the first time to estimate the change in areas since 1987-91.

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. The NYTLALAND 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 woodland (forest and birch shrubland), map of revegetated land, map of ditches, maps of drained land and map of cultivated land. Short description of these maps is provided below.

7.3 Data Sources

The present CRF reporting is based on land use as recorded from IGLUD (Icelandic Geographical Land Use Database), activity data and mapping on afforestation and deforestation and natural birch forest and birch shrubland from Icelandic Forest Research (IFR) and on revegetation from the Soil Conservation Service of Iceland (SCSI), time series of Afforestation and reforestation, Cropland and Grassland categories, including revegetation, drainage and cropland abandonment, and of reservoirs. Data on liming is based on sold $CaCO_3$ and imported synthetic fertilizers containing chalk or dolomite.

7.3.1 The Icelandic Geographic Land Use Database (IGLUD)

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 the 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.

The data sources of IGLUD are described below and process of compiling the data to a land use map is described in more details in (Gudmundsson et al. 2013). Description of field work for collecting land information for the database and some preliminary results can be found in (Gudmundsson et al. 2010).

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.

7.3.2 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:

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 and 70% of the lowlands below 400 m elevation 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 for most categories. The categorization used divides the land into twelve classes, vegetation covers ten 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.

Table 7.1. The original 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 and perpetual snows	Glaciers

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.

Before compiling the NYTJALAND classes into IGLUD each land cover class is converted to a separate map layer. In this submission revised version of the map layers “Natural birch forest > 2m” and “Natural birch woodland < 2m” is used. The NYTJALAND map layer of Glaciers and perpetual snows is not used in the compilation of IGLUD.

The two level NYTJALAND database modified as described above is the primary data source of IGLUD.

IS 50 v 3.2

The IS 50V 3.2 geographical database of the National Land Survey of Iceland (NLSI) includes eight map layers. From that database four map layers are used in IGLUD i.e. “town and villages”, “Airports” and “Roads”. The map layer of IS 50V 3.2 Glaciers and perpetual snows is also used in the IGLUD compilation as in last submission replacing the previous NYTJALAND map layer of Glaciers.

Maps of Forest

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

Maps of Land being revegetated

The SCSI collects information on revegetation activities. The majority of revegetation activities since 1990 are already mapped and available in a Geographical Information System (GIS). Mapping of the activity “Farmers revegetate the land” (FRL) has now been completed and merged with other activities since 1990. FRL is a cooperative revegetation activity between SCSI and voluntary participating farmers. The mapped area forms 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 NIRA but will be added as the data become available. Unmapped activities are included as activity in CRF and the difference in maps and activity is balanced against other land use (see chapter 7.3.9) The mapping of revegetation taking place before 1990 is less reliable with regard to activity, as the documentation often focuses on location rather than the activity. The category Revegetated land in IGLUD is based on these maps.

Maps of ditches and Drained land

Extensive drainage of wetland took place in Iceland mostly in the period 1940-1985, although still ongoing in lesser scale. This drainage was aided by governmental subsidies. Only a minor part 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. Part of this land has since been afforested or converted to Settlement. 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. In one region records have been updated annually (Kristján Bjarndal Jónsson personal communication). These records are applied to estimate the new drainage in the country. All ditches recognizable on satellite images (SPOT 5) have recently been digitized in a cooperative effort of the AUI and the NLSI (Figure 7.1).

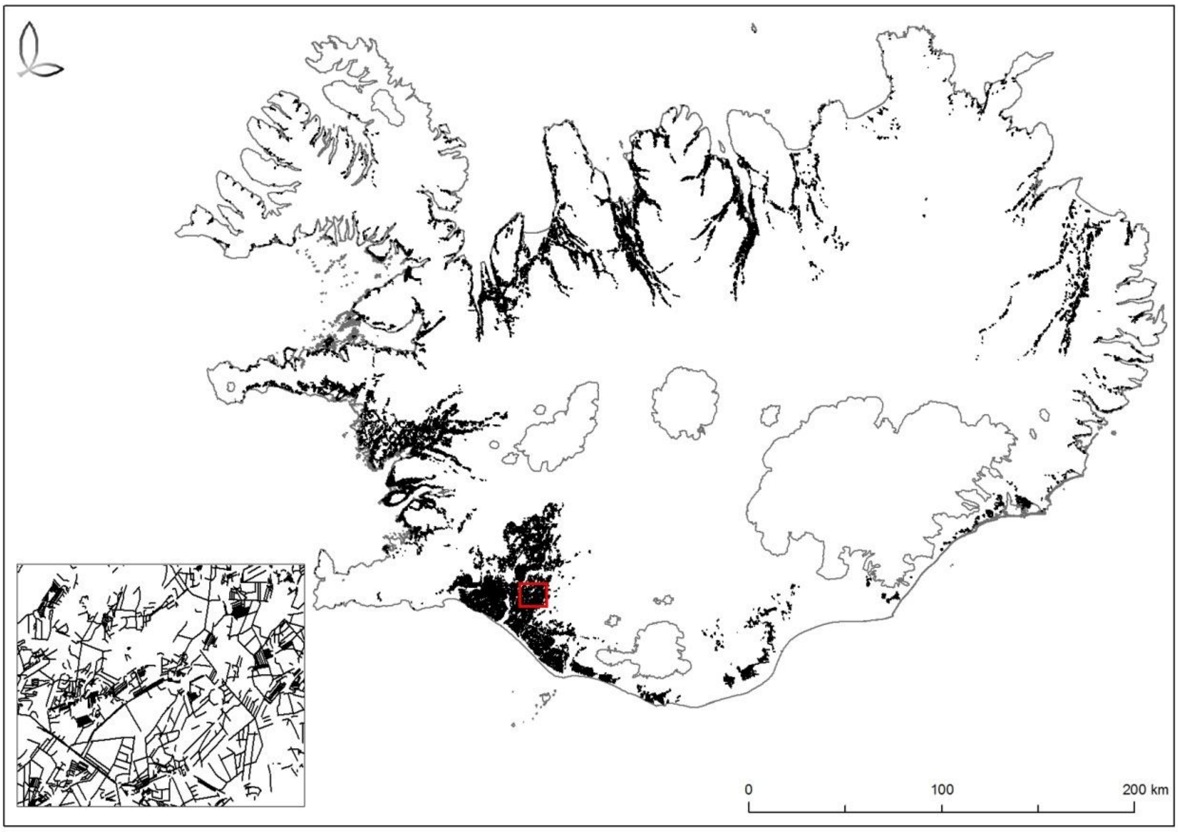

Figure 7.1. Map of Iceland showing all digitized ditches. (AUI 2008).

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 layer Drained land was prepared from map of ditches applying a 200 m buffer zone on every ditch. From that area the overlap with following map layers was excluded; Sparsely vegetated land (ID: 603 and 604), Partly vegetated land (ID: 506 and 509), Lakes and Rivers (ID: 404 and 405), Shrubs and forest (ID: 507) and Natural birch woodland <2 m (ID: 515). 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 Grassland subcategory “Grassland organic soil” is identified in IGLUD on basis of this map.

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 and wetness. The wetland vegetation can dominate in these areas for long time after drainage if no other disturbances occur. The land classified as Wetland converted to grassland has not been ploughed or harrowed and wetland vegetation is still prevailing in many areas. The separation of semi-wetland and wetland in the Semi-wetland/wetland complex is not available in the present dataset. There is therefore large uncertainty regarding these areas and the exclusion of that land as whole from the map layer drained land is not considered justifiable.

Maps of cultivated Land

The map layer Cropland was also produced in cooperation with NLSI. The digitization was completed in 2009 by AUI. The map layers of the NYTJALAND database are prepared with remote sensing of satellite images as described above. All Cropland in the NYTJALAND map layers named “Cultivated land” and “Cropland and pasture” are in the compilation process excluded by this map layer as these map layers are beneath the Cropland map layer in the compilation hierarchy (see below). In IGLUD this map layer represent the Cropland category. The drained organic soil within Cropland is mapped on basis of density analyses of the digitized ditches (Gísladóttir et al. 2010).

Maps of reservoirs

The previous map of reservoirs has been supplemented with new map layer prepared by AUI on basis of available information (Sigurðsson 2002) and local knowledge. Included in this supplementary map are many smaller reservoirs and reservoirs managed by others than the main power plant company Landsvirkjun. This map layer needs still to be verified.

Map of zone of recently retreated glaciers.

The comparison of previous map of glaciers and perpetual snows to the one from IS 50v 3.2 reveals less area included in the IS 50 v3.2. To meet this shrinkage of glaciers and perpetual snows a separate map layer was prepared for those areas recently exposed.

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	Hierarchy of map layers
1.**Settlement**		Towns and villages	101	4
		Airports	102	5
		Roads with buffer zone	103	6
2.Forest land	Cultivated forest	Forest cultivations	201	12
		Forest cultivations 1960-1989	202	7
		Forest cultivations 2000-2009	203	9
		Forest cultivations 1990-1999	204	8
		Forest cultivations >2m	205	10
		Forest cultivations 0-2m	206	11
	Natural birch forest	Natural birch forest >2m	205	13
3.**Cropland**	Cropland mineral soil	Cropland	301	19
	Cropland organic soil	Cropland with ditch density 10-15 km km^{-2}	302	16
		Cropland with ditch density 15-20 km km^{-2}	303	17
		Cropland with ditch density > 20 km km^{-2}	304	18
4.**Wetland**	Other wetlands	Semi-wetland (wetland upland eco-tone)	401	37
		Wetland	402	38
		Semi-wetland/wetland complex	403	39
	Rivers and lakes	Lakes and rivers 1	404	14
		Lakes and rivers 2	405	15
	Reservoirs	Reservoirs 1	406	1
		Reservoirs 2	407	2
5.Grassland	Natural birch shrubland	Natural birch Woodland <2m	515	24
	Other grassland	Grassland (true grassland)	501	26
		Richly vegetated heath land	502	27
		Cultivated land	503	35
		Poorly vegetated heath land	504	28
		Mosses	505	30
		Partly vegetated land (1)	506	29
		Shrubs and forest	507	25
		Grassland, heath-land shrubs and forest complex	508	33
		Partly vegetated land (2)	509	34
		Cropland and pasture	510	36
	Revegetated land	Revegetation before 1990	513	21
		Revegetation activity 1990-2010	514	20
		Farmers revegetation	511	22
	Drained grasl.	Drained land	512	23

Table 7.2 continued				
Land use categories	**Sub categories**	**Map layers included in land use category**	**ID**	**Hierarchy of map layers**
6.Other land	Other land	Historical lava fields with mosses (1)	601	31
		Historical lava fields with mosses (2)	602	32
		Sparely vegetated land (1)	603	41
		Sparely vegetated land (2)	604	42
		Zone of recently retreated glaciers	606	40
	Glaciers	Glaciers and perpetual snow	605	3

Map of historical lava fields covered with mosses

To separate land with almost full vegetation cover but very little or less than 20% cover of vascular plant, geological maps and vegetation maps were compared to identify areas of historical lava fields covered with mosses.

Besides these main sources of information few derived maps are used in the compilation of the land use classes in IGLUD. These maps are ditch density maps of cropland, map of drained land and roads with defined buffer zones. The map layers used in compiling the IGLUD map are listed in Table 7.2. The compilation process is done by overlay analyses in GIS (Geographical Information System). In that process the hierarchy of the map layers plays an important role, as the map layer higher in the hierarchy replace all overlaid pixels in map layer of lover order with its own pixels. Thus e.g. the pixels common to the map layer "Reservoirs 1", with hierarchy order 1, and the map layers "Reservoirs 2","Lakes and rivers 1 and 2"with hierarchy order 14 and 15 are defined as reservoirs. The criteria applied to determine the hierarchical order of map layers and the compilation process is further described in (Gudmundsson et al. 2013).

7.3.3 Definitions of IGLUD 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.

7.3.4 Broad Land Use Categories

Settlements: All areas with included within map layers "Towns and villages" and "Airports" as defined in the IS 50 v3.2 geographical database. Also included as Settlement are roads classified with at least 15 m wide road zone including primary and secondary roads.

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 a minimum width of 20 m and also land which currently falls below these thresholds but is expected to reach them in situ at mature state.

Cropland[4]: 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 does 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.

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 subject 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. The revegetation activity can also result in such land being converted to Cropland, Wetland or Settlement. Forest land is excluded by definition.

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.

7.3.5 Subcategories applied in land use map

In the land use map prepared for this year’s submission land is divided to 17 land use classes.

Forest land is represented by four classes prepared through combination of available forest map layers from IFR. The classes are Natural birch forest, Forest planted before 1990, Forest planted since 1990 and Planted forest of unknown age.

Cropland is presented as two classes i.e. Cropland on mineral soil and Cropland on organic soil. The separation of these classes is based on analyses of the digitized ditches (Gísladóttir et al. 2010), where all cropland with the density of ditches network higher than 10 km/km^2 is defined as organic soil. The remaining Cropland is accordingly defined as mineral soil.

Grassland is in the land use map represented as five classes. The “Natural birch shrubland” is as mapped by IFR. The classes “Revegetation before 1990” and “Revegetation since 1990”

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

are as mapped by SCSI. The class "Grassland organic" soil is identified on basis of the map layer drained land. The class "Grassland other" is all other land included as Grassland.

Wetland is in the land use map represented as three classes; Lakes and rivers, Reservoirs and Other Wetland.

Settlement is in the land use map represented as one class.

Other land is represented as two classes; Glaciers and perpetual snow and Other land.

7.3.6 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 (Table 7.2) 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 criteria applied to rank map layers in to the hierarchical order are described elsewhere (Gudmundsson et al. 2013). The map layers were then compiled according to this order using ERDAS imaging 9.3, software. Considering the remaining area of each map layer the layers were grouped to estimate the total area of mapped land use categories. It is possible that the compilation process leads to the reallocation of all area originally allocated to a certain land use category to other land use categories. This applies e.g. to both the map layers "Cultivated land (ID-503)" and "Cropland and pasture (ID-510)" where the area after compilation includes no cropland and is accordingly moved to the Grassland category.

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 considerably in coming years, including allocation of land between categories and to subcategories. The area of each land use category in IGLUD as they appear from the compilation process is used as first estimates for the CRF. Because of the difference in IGLUD mapping area and direct area estimate of three land use categories it is not possible to use the IGLUD mapping area directly in the CRF for all categories.

The land use categories and their area as they appear on the IGLUD map are listed in Table 7.3. Also listed in the same table is the comparative area as applied in the CRF after the modification described below (see Chapter 7.3.9). 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 coherence between the IGLUD maps and area reported in CRF.

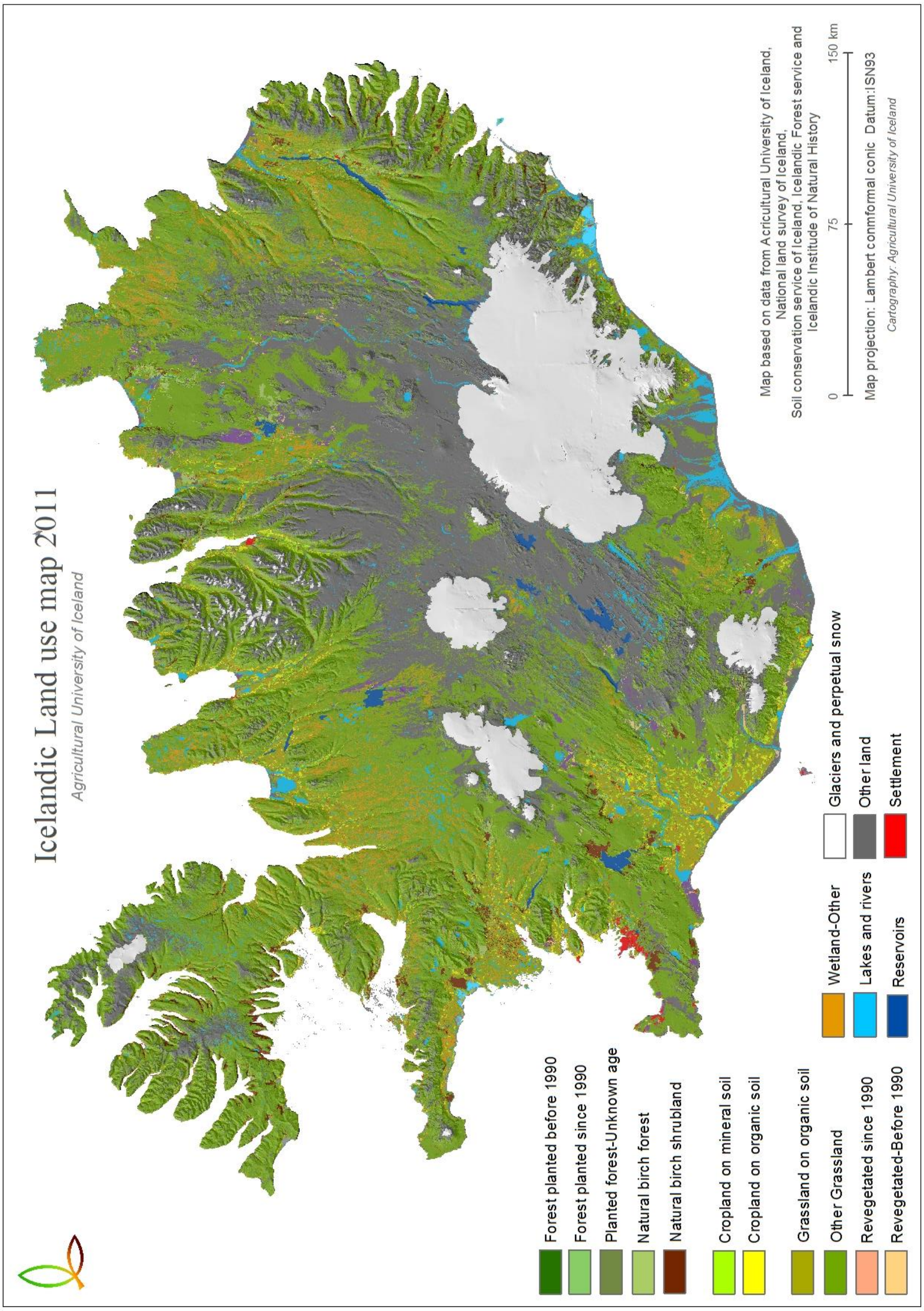

Figure 7.2. Map of Iceland showing the present status of land use classification in IGLUD.

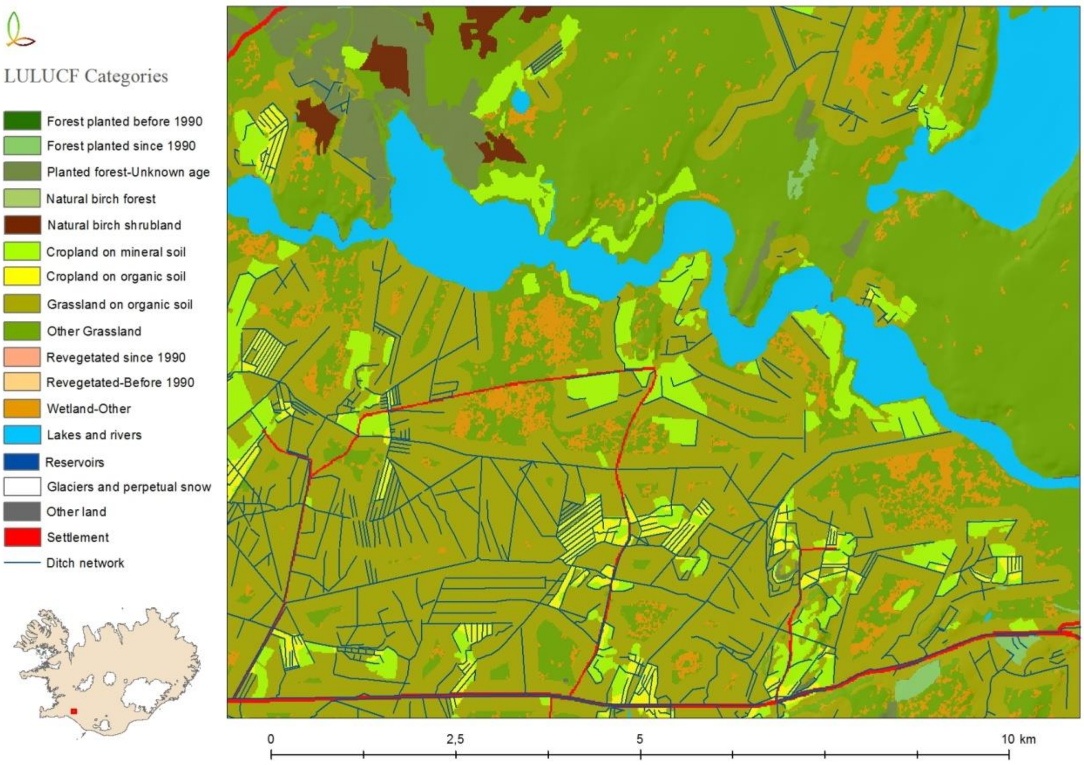

Figure 7.3. Enlarged map (I) showing details in IGLUD land use classification.

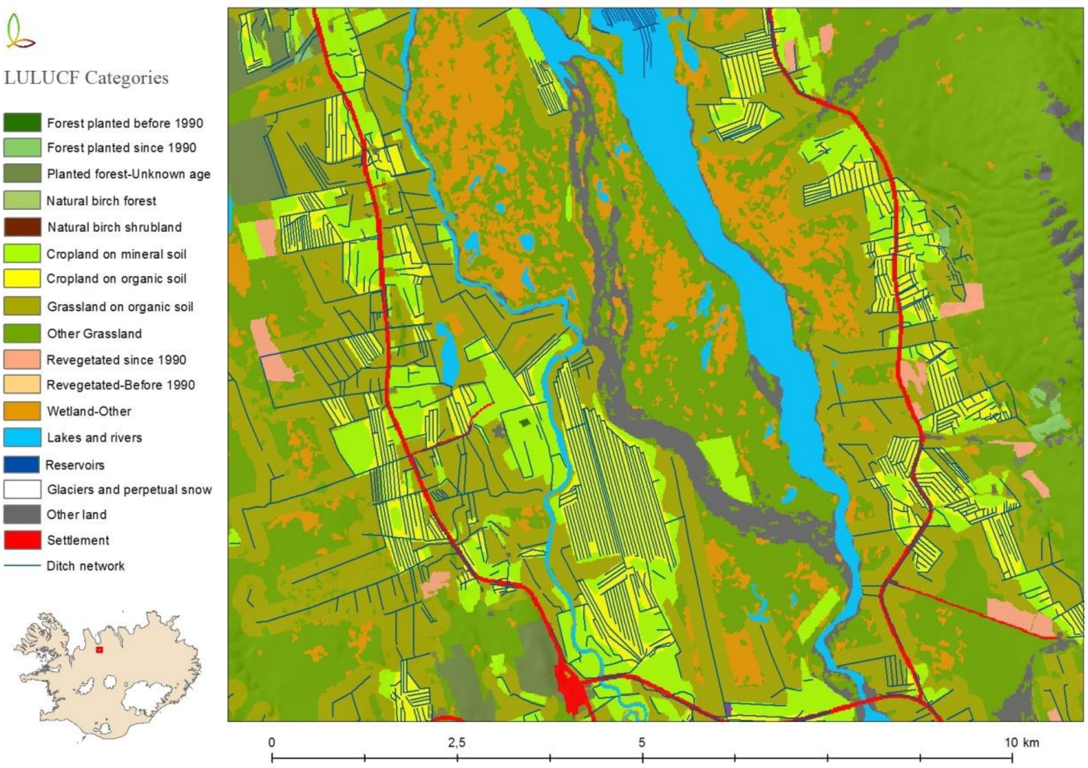

Figure 7.4. Enlarged map (II) showing details in IGLUD land use classification

7.3.7 Time Series

Time series of last submission were extended to the present inventory year. All land use categories for which emission or removal is reported are now represented by time series. Thus independent time series are available for; afforestation, deforestation, expansions of natural birch forest and shrubland, cropland converted to forest land, other land converted to forest land, wetland drainage, land converted to cropland, cropland abandonment, revegetation and establishment of new reservoirs. All other reported time series on land use are derivates of these time series.

Most of the data time series are based on hold information about changes new input or output to or from the area of the respective category without assigning the origin of the input or destination of the output to certain other land use category. The time series for cropland are thus constructed from data based on records of new cultivations each year and available estimates of abandoned cropland at specific points in time. This data does not specifically state which land use categories were turned to cropland or what became of the abandoned fields. The evaluation of cropland origin as it appears in the time series is based on two assumptions. First assumption is that land that has been converted to cropland originated mostly from either Grassland on mineral soil or from other wetland. The second assumption is that the ratio of new cropland of wetland origin has been constant. This ratio has in the construction of the time series been adjusted to ratio of wetland originated hayfields evaluated in the period 1990-1993 (Þorvaldsson 1994).

The destination of abandoned cropland is assumed as first approach to be all to the Grassland category, and the ratio of organic and mineral soil of abandoned cropland is the same as the ratio within the cropland category on the year of abandonment. This time series is then corrected according to an independent time series of “Cropland converted to Forestland”. The construction of time series will be further described elsewhere (Gudmundsson in prep).

7.3.8 CRF subcategories and their relation to Land use map.

In the CRF tables land use categories are divided to subcategories. This division, and how the subcategories are related to the categories of the land use map, is described below.

Forest land

Two subcategories are defined, natural birch forest and cultivated forest. Both categories are further divided according to age of afforestation to forest land remaining forest land and land converted to forest land. Afforested land is forest where planted or directly seeded trees or trees naturally generated from cultivated forests or natural birch forest.

Afforestation is considered one year old in the autumn of the year the seedlings were planted[5]. For direct seeded or naturally regenerated forest assessed age is used to determine the year of initiation. In general the CRF subcategories are not directly represented by the categories of the land use map. In CRF Forest land is reported in following subcategories:

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

Afforestation older than 50 years: The area reported for this category as all Forest land categories is according to IFR activity data. Within the land use map this category is to be found in the categories Forests planted before 1990 and Planted forests of unknown age.

Natural birch forest: Forest where the dominant species is *Betula pubescens* that has regenerated naturally from sources of natural origin. All land mapped as Natural birch forest is included in this category. Considerable part of the area reported as Natural birch forest is located in areas mapped as grassland category Natural birch shrubland.

Plantations in natural birch forest: Within the land use map this category is to be found mostly in the categories Forest planted before 1990 and Planted forest of unknown age.

Afforestation 1-50 years old: This category is reported under both, Grassland converted to Forest land – Cultivated forest, Grassland converted to forest land - Natural birch forest expansion, Cropland converted to Forest land and Other land converted to Forest land. In the land use map there is no separation of these categories except between the Natural birch forest expansion and the cultivated forest. The area reported as the cultivated part of this category is to be located in areas mapped as Forest planted since 1990, Forest planted before 1990 and Planted forest of unknown age. The Natural birch forest expansion is either located on the maps of natural birch forest or on Other Grassland.

Cropland

In CRF Cropland is reported in the subcategories; Cropland remaining Cropland, Grassland converted to Cropland and Wetland converted to Cropland. Cropland remaining Cropland includes both area of organic and mineral soil and related to accordingly to both map units. Grassland converted to Cropland is only reported on mineral soil and therefore only relates to that mapping unit. Likewise Wetland converted to Cropland contains only organic soil and relates to the mapping unit Cropland on organic soil.

Grassland

In CRF Grassland is reported as ten subcategories. Two of them i.e. Cropland converted to Grassland and Cropland abandoned for more than 20 years are related to the land use map unit Cropland. The two CRF categories; Wetland drained for more than 20 years and Wetland converted to Grassland are together represented by the mapping unit Grassland on organic soil. The area of the CRF categories Natural birch shrubland old and Natural birch shrubland recently expanded into Other Grassland is all assumed to be included within the mapping unit Natural birch shrubland. The land use mapping unit Revegetated since 1990 is all included in CRF subcategory Other land converted to Grassland- Revegetation since 1990. Some area of that CRF subcategory is related to the mapping units Other Grassland and Other land. The land use mapping unit Revegetated before 1990 is related to the CRF categories, Revegetated land older than 60 years, and Other land converted to Grassland-Revegetation before 1990. The CRF subcategory Other Grassland is represented by the land use mapping unit Other Grassland taken into account the claims of other CRF categories to that mapping unit as described above.

Wetland

In CRF Wetland is reported as six first and second order subcategories. The CRF category “Lakes and rivers” is represented by the land use mapping unit with same name. Similarly the CRF category Other Wetland is represented by synonymous mapping unit. The land use mapping unit Reservoirs represent collectively the remaining CRF Wetland subcategories; Reservoirs, High SOC, Medium SOC and Low SOC, respectively under Wetland remaining wetland, and Other land converted to Wetland subcategories.

Settlement

In CRF Settlement is reported as two subcategories, i.e. Settlement remaining Settlement, and Forest land converted to Settlement. Only one mapping unit for Settlement is presented in the land use map.

Other land

IN CRF “Other land” is reported as undivided. There are two land use mapping units representing “Other land” i.e.; Glaciers and perpetual snows, and “Other land”. Part of the mapping unit “Other land” is represented in CRF as Revegetation since 1990.

7.3.9 Estimation of Area of Land Use Categories used in the CRF LULUCF Tables

The area reported in CRF is based on, direct activity data, time series prepared or estimated from the land use map. The mapped area in many cases does not match completely the activity data or area estimated through time series. To be able to estimate the area of land use categories from the land use map the difference between activity data or time series, and the relevant mapping unit needs to be accounted for and area needs to be transferred between categories. In Table 7.3 the mapping units in the land use map are listed and their area compared to area reported for relevant CRF category. The adjustments made are described below.

The adjustments are based on the area of categories according to reported area from activity data or as estimated from time series for the inventory year 2011.

Forest land: The total area of cultivated forest as reported by IFR is for the year 2011 37.92 kha but mapped area of all forest cultivations is 51.97 kha. The difference 14.05 kha is added to the area of Other Grassland. The area of Natural birch forest as reported by IFR for the CRF is 95.51 kha, including forests at least 2m high expecting to reach that height *in situ* at maturity. The mapping unit including all mapped birch forest areas not considering height at maturity is 36.58 kha. The difference 58.94 kha is added to the category from the mapped area of Natural birch shrubland and mapping unit Other Grassland 46.37 kha and 12.57 kha respectively.

Cropland: The total area of Cropland as estimated from AUI cropland time series is 129.94 kha but area mapped as Cropland is 169.03 kha. The difference 40.65 kha is added to the area of Grassland.

Grassland: The area of Grassland organic soil mapping unit is 339.83 kha. The total area of organic soils reported in the Grassland category is 358.12 kha. Thereof 0.24 kha and 14.08 kha are included respectively as Natural birch shrubland and Cropland organic soils. The remaining 343.80 kha reported is 3.97 kha larger than the mapping unit “Grassland organic soil”. That area is accordingly included in the area of “Grassland organic soils” and consequently subtracted from the area of “Other wetland” mapping unit. This correction represents the estimated drained areas since 2008. The area of Natural birch shrubland as estimated by IFR and reported in CRF is 50.81 kha but the area included in the mapping unit is 97.18 kha. The difference is 46.37 kha and was added to the area of Natural birch forest, as explained above. The area of land revegetated before 1990 is in CRF represented in two categories i.e. “Grassland remaining Grassland-Revegetated land older than 60 years”, and “Other land converted to Grassland-Revegetation before 1990” with total area 165.36 kha. The area of “Revegetated land before 1990” mapping unit is 18.27 kha the difference 147.09 kha is added to the area of the mapping unit from the Grassland mapping unit. The total area of Revegetation since 1990 reported in CRF is 87.09 kha but the mapping unit Revegetated land since 1990 is 73.09 kha. The difference is 14.00 kha and was added to the area of the mapping unit with half of it coming from mapping unit “Other land” (7.00) and half from Grassland mapping unit. The area of mapping unit Other Grassland is then balanced against the difference of total area of the Grassland mapping unit and all other mapping units included as Grassland as resulting from the above described corrections.

Wetland: The area reported in CRF and the area of the mapping units of, Lakes and rivers, and Reservoirs are the same. The area reported in CRF for Other wetland is 396.62 kha while the area of the mapping unit is 400.59 kha. The difference, 3.97 kha, is added to the mapping unit Grassland organic soil

Settlement: The area of Settlement reported in CRF is the same as the area of the mapping unit.

Other land: The area of “Other land” as reported in CRF is 3,999.96 kha but the area included in the mapping unit “Other land” is 4,006.96 kha the difference is 7.00 kha which was added to the Revegetation since 1990 mapping unit.

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	51.86	Settlement	51.86
Forest Land	88.54	Forest Land	133.43
Natural birch forest	36.58	Natural birch forest	95.51
Cultivated forest	51.97	Cultivated forest total	37.92
Cropland	169.68	Cropland	129.03
Cropland on organic soil	55.18	Cropland organic soil	57.73
Cropland on mineral soil	114.45	Cropland mineral soil	71.30
Wetland	718.47	Wetland	714.50
Lakes and Rivers	259.99	Lakes and rivers	259.99
Reservoirs	57.90	Reservoirs	57.90
Other wetlands	400.59	Other wetlands	396.62
Grassland	5,252.96	Grassland	5,259.68
Natural birch shrubland	97.18	Natural birch shrubland	50.81
Other grassland	4,724.60	Other grasslands	4,569.11
Grassland organic soil	339.83	Grassland organic soil	358.12
Revegetated land (RL)	91.35	OL converted to GL + RL older than 60 years	252.44
RL before 1990	18.26	RL before 1990	165.36
RL since 1990	73.09	RL since 1990	87.09
Other Land	4,006.96	Other Land	3,999.96
Glaciers and perpetual snow	1,086.61	Glaciers and perpetual snow	Not rep

7.3.10 Land Use Change

Emission/removal of GHG due to land use changes is reported for eleven types of land conversions, ten of which were reported in last submission. The conversion “Cropland to Forest land” is reported additionally in this submission (Table 7.4). Time series of land use changes have been extended to the present inventory year.

Table 7.4. Land use classification used in GHG inventory 2011 submitted 2013 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		133.43	3.73
Forest Land remaining Forest Land		87.27	0.50
	Afforestation older than 50 years	0.69	0.05
	Natural birch forest	85.58	0.45
	Plantation in natural birch forest	1.01	
Land converted to Forest Land		46.16	3.24
Cropland converted to Forest Land	Afforestation 1-50 years old	0.85	0.29
Grassland converted to Forest Land		38.76	2.94
	Afforestation 1-50 years old	28.83	2.94
	Natural birch forest expansion	9.94	
Other Land converted to Forest Land	Afforestation 1-50 years old	6.55	
Total Cropland		129.03	57.73
Cropland remaining Cropland		123.63	54.86
Land converted to Cropland		5.40	2.87
Grassland converted to Cropland		2.53	
Wetlands converted to Cropland		2.87	2.87
Total Grassland		5,259.68	358.12
Grassland remaining Grassland		4,955.44	319.47
	Natural birch shrubland-old	45.53	0.24
	Revegetated land older 60 years	1.99	
	Wetland drained for more than 20 years	314.63	314.63
	Cropland abandoned for more than 20 years	18.89	4.60
	Other Grassland	4,569.11	
	Natural birch shrubland – recently expanded into “Other Grassland”	5.29	
Land converted to Grassland		304.25	38.64
Cropland converted to Grassland		24.63	9.48
Wetlands converted to Grassland		29.16	29.16
Other Land converted to Grassland		250.45	
	Revegetation before 1990	163.37	
	Revegetation since 1990	87.09	

Table 7.4 continued			
Land-Use Category	**Sub-division**	**Area (kha)**	**Area of organic soil (kha)**
Total Wetlands		714.50	
Wetlands remaining Wetlands		688.08	
	Lakes and rivers	259.99	
	Other wetlands	396.62	
	Reservoirs	31.47	
Land converted to Wetlands		26.42	
Grassland converted to Wetlands		7.95	
	High SOC	0.99	
	Medium SOC	6.96	
Other Land converted to Wetlands		18.48	
	Low SOC	18.48	
Total Settlements		51.86	
Settlements remaining Settlements		51.81	
Land converted to settlements		0.05	
Forest land converted to Settlement		0.05	
Total Other Land		3,999.96	
Other Land remaining Other Land		3,999.96	

The conversion period varies between categories as explained in relevant chapters below. Real time countrywide recording of land use changes is still limited in Iceland and only available for few of the land use categories requested in CRF. For some land use categories like Settlements, changes are recorded at municipal level, but have not been assembled. Regular land use surveys have not been practiced in Iceland. In preparing this submission, 42 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.

Land use change matrix*:* In Table 7.5 the on-going land use changes are summarized. As land use changes are reported with different conversion period extending from 20-60 years the initial stage of all categories cannot be assigned to a certain year. The area summed in the last row of the table can be seen as the area of the category prior to all ongoing conversions and the last column as the area of each category when all ongoing conversion are completed.

Table 7.5. Land use change matrix 2011 showing ongoing changes in land use and the area prior to and at the end of defined conversion period. The numbers in each cell show the area converted from „column“ to „row“.

To\From [Kha]	Forest land	Cropland	Grassland	Wetland	Settlement	Other land	Total at end of conversion period
Forest land	87,27	0,85	38,76	IE	NO	6,55	133,43
Cropland	NE	123,63	2,53	2,87	NO	NE	129,03
Grassland	NO	24,63	4955,44	29,16	NO	250,45	5259,68
Wetland	NO	IE	7,95	688,08	NO	18,48	714,50
Settlement	0,05	NE	NE	NE	51,81	NE	51,86
Other land	NE	NE	NE	NE	NE	3999,96	3999,96
Total the year before conversion period	87,32	149,11	5004,68	720,11	51,81	4275,43	10288,47

7.3.11 Uncertainties QA/QC

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 with previous submissions. The new time series applied are also considered to have substantially improved the quality of the data. All map layers used have been visually controlled by the AUI GIS laboratory staff during the preparation process and compared with local knowledge. This internal quality control has led to exclusion of many faults arising during the process establishing good confidence in the maps. This control is still only qualitative.

Uncertainty estimate for following maps estimates is provided; Cropland total area (including abandoned Cropland), Forest land and revegetation activity area. The reliability of the map of ditches has also been evaluated (see relevant chapters).

All map layers originating from the full scale NYTJALAND classification have been controlled through extensive ground truthing process. The map layers of Settlement are based on NLSI IS 50 maps and the maps of forest 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.

The uncertainty of area of reported categories is set at 20% for all categories except revegetation and Forest land, where more precise evaluations are available.

7.3.12 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. Presently, new RapidEye satellite images from the year 2011 of most of Iceland´s lowlands have become available and their analysis is pending. 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. In this submission some of this data is applied. More data for estimating the size of different C-pools of the land use categories is therefore expected to be available in the coming years.

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.

7.4 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 7.6, Table 7.7, and Table 7.8.

Table 7.6. Summary of method and emission factors applied on CO_2 emission calculation.

Source/sink	Area (kha)	Method	EF	Gg Emission/Removal (-)
Forest Land remaining Forest Land	87.27			-31.27
Afforestation older than 50 years	0.69			-7.15
Living biomass		T3		-7.17
Dead organic matter		NE		
Mineral soil		NE		
Organic soil	0.05	T1	D	0.03
Natural Birch forest	85.58			-12.32
Living biomass		T3		-12.58
Dead organic matter		NE		
Mineral soil		NE		
Organic soil	0.45	T1	D	0.26
Plantations in natural birch forest	1.01			-11.81
Living biomass		T3		-11.81
Dead organic matter		NE		
Mineral soil		NE		
Organic soil		NO		
Land converted to Forest Land	46.16			-219.40
Cropland converted to Forest Land	0.85			-2.31
Living biomass		T3		-1.30
Dead organic matter		T2	CS	-0.44
Mineral soil		T2	CS	-0.75
Organic soil		T1	D	0.17
Grassland converted to Forest Land	38.76			-185.87
Afforestation 1-50 years old - Cultivated forest	28.83			-157.55

Table 7.6 continued				
Source/sink	Area (kha)	Method	EF	Gg Emission/Removal (-)
Living biomass		T3	CS	-109.68
Dead organic matter		T3,T2	CS	-14,90
Mineral soil	26.18	T2	CS	-34,68
Organic soil	2.92	T1	D	1,73
Afforestation Natural birch forest 1 - 50 years old	9.94			-28.33
Living biomass		T2	CS	-9.88
Dead organic matter		T2	CS	-5.14
Mineral soil		T2	CS	-13.31
Organic soil	NE			
Other Land converted to Forest Land	6.55			-31.21
Afforestation 1-50 years old	6.55			-31.21
Living biomass		T3		-15.52
Dead organic matter		T2	CS	-3.38
Mineral soil		T2	CS	-12.31
Organic soil	NO			
Cropland remaining Cropland	123.63			1,005.76
Living biomass		T1		NO
Dead organic matter		T1		NO
Mineral soil		NE		NE
Organic soil	54.86	T1		1,005.76
Agricultural liming	NA			2.22
Limestone $CaCO_3$		T1	D	0.32
Dolomite $CaMg(CO_3)_2$		T1	D	0.39
Shellsand (90% $CaCO_3$)		T2	CS	1.51
Land converted to Cropland	5.40			64.43
Grassland converted to Cropland	2.53			3.95
Living biomass		T1	CS	4.91
Dead organic matter		IE		
Mineral soil		T1	CS	-0.95
Organic soil	NO			
Wetlands converted to Cropland	2.87			60.48
Living biomass		NE		7.92
Dead organic matter		IE		
Mineral soil	NO			
Organic soil	2.87	T1	D	52.54
Grassland remaining Grassland	4,955.44			274.27
Natural birch shrubland-old	45.53			-3.29
Living biomass		T3	CS	-3.51
Dead organic matter	NE			
Mineral soil	NE			
Organic soil		T1	D	0.22
Revegetated land older than 60 years	1.99	NO		
Wetland drained for > 20 years	314.63			288.41
Living biomass		NE		
Dead organic matter		NO		
Mineral soil		NO		
Organic soil	314.63	T1	D	288.41
Cropland abandoned for > 20 years	18.89			4.22
Living biomass		NO		
Dead organic matter		NO		
Mineral soil		NO		
Organic soil	4.60	T1	D	4.22
Other Grassland	4,569.11	NE		
Natural birch shrubland -recently expanded into Other Grassland	5.29			-15.07
Living biomass		T2	CS	-5.25

Table 7.6 continued				
Source/sink	Area (kha)	Method	EF	Gg Emission/Removal (-)
Dead organic matter		T2	CS	-2.73
Mineral soil		T2	CS	-7.08
Organic soil		NE		
Land converted to Grassland	304.25			-447.48
Cropland converted to Grassland	24.63			49.23
Living biomass		T1	CS	-47.78
Dead organic matter		IE		
Mineral soil	15.15	T2	CS	5.79
Organic soil	9.48	T1	D	91.23
Wetlands converted to Grassland	29.16			26.73
Living biomass		NO		
Dead organic matter		NO		
Mineral soil	NO	NA		
Organic soil	29.16	T1	D	26.73
Other Land converted to Grassland	250.45			-523.45
Revegetation before 1990	163.37			-341.44
Living biomass		T2	CS	-34.14
Dead organic matter		IE		
Mineral soil	163.37	T2	CS	-307.30
Organic soil	NO			
Revegetation since 1990	87.09			-182.01
Living biomass		T2	CS	-18.17
Dead organic matter		IE		
Mineral soil	87.09	T2	CS	-163.83
Organic soil	NO			
Wetlands remaining Wetlands	688.08			
Lakes and rivers	259.99	NA		
Other wetlands	396.62	NA		
Reservoirs	31.47	NA		
Land converted to Wetlands	26.42			9.72
Grassland converted to Wetlands	7.95			8.83
High SOC CO_2	0.99	RA/T2	CS	2.75
Medium SOC CO_2	6.96	RA/T2	CS	6.09
Other Land converted to Wetlands	18.48			0.89
Low SOC CO_2	18.48	RA/T2	CS	0.89
Settlements remaining Settlements	51.81	NA		
Land converted to Settlement	0.05			0.46
Forest land converted to Settlement	0.05			0.46
Living biomass		T3		0.25
Dead organic matter		T2	CS	0.09
Soil		T2	CS	0.11
Other Land remaining Other Land	3,999.96	NA		

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.

Table 7.7. Summary of method and emission factors applied on CH_4 emission calculations.

Source/sink	Area			Gg Emission/	
	kha	Method	EF	Removal (-)	Gg CO_2 -eq
Wetlands remaining Wetlands	688.08				
- **Lakes and rivers**	259.99	NA			
- **Other wetlands**	396.62	NA			
- **Reservoirs**	31.47	NA			
Land converted to Wetlands	26.42			0.40	8.33
Grassland converted to Wetlands	7.95			0.36	7.57
- **High SOC CH_4**	0.99	RA/T2	CS	0.11	2.38
- **Medium SOC CH_4**	6.96	RA/T2	CS	0.25	5.19
Other Land converted to Wetlands	18.48			0.04	0.75
- **Low SOC CH_4**		RA/T2	CS	0.04	0.75

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.

Table 7.8. Summary of method and emission factors applied on N_2O emission calculations.

Source/sink	Area kha	Method	EF	Gg Emission / Removal (-)	Gg CO_2 eq
Forest Land remaining Forest Land	87.27				
- Mineral Soil					
- Organic Soils N_2O	0.50	T1	D	0.00	0.14
Land converted to Forest Land	46.16				
- N_2O fertilizers		T3	D	0.00	0.13
- Mineral Soil		NE			
- Organic Soils N_2O	3.24	T1	D	0.00	0.94
Cropland remaining cropland	123.63				
- Mineral Soil		NE			
- Organic Soils N_2O	54.86	IE			
Wetland converted to cropland	2.87				
- Mineral Soil	NO	NA			
- Organic Soils N_2O	2.87	IE			
Grassland remaining Grassland	4,955.44				
Cropland abandoned for more than 20 years	18.89				
- Organic Soils N_2O	4.60	T2	CS	0.00	0.99
Wetland drained for more than 20 years	314.63				
- Organic Soils N_2O	314.63	T2	CS	0.22	67.43
Natural birch shrubland-old	45.53				
Organic Soils N_2O	0.24	T2	CS	0.00	0.05
Land converted to Grassland	304.25				
Cropland converted to Grassland	24.63				
- Organic Soils N_2O	9.48	T2	CS	0.01	3.30
Wetlands converted to Grassland	29.16				
- Organic Soils N_2O	29.16	T2	CS	0.02	6.25

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.

7.5 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 National Forest Inventory (NFI). 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 19^{th} 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.

The estimate of the natural birch woodland is totally revised both in area, stock change and methodology.

Natural birch woodland is included in the IFR national forest inventory (NFI). In the NFI 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 is placed on the intersection of 1.5 x 3.0 km grid (Snorrason 2010). The part of natural birch woodland defined as forest (reaching 2 m or greater in height at maturity *in situ*) is estimated on basis of four data sources; data obtained through plot measurement in 2005-2011, on tree biomass data sample from 1987, survey from 1987-1991 and on-going remapping of natural birch woodlands 2010-2014.

By analysing the age structure in the natural birch woodland, already remapped in the on-going remapping project, that does not merge geographically the old map from the survey in 1987-1991; it is possible to re-estimate the area of natural birch woodland in 1987-1991 and the area of birch woodland today. Preliminary results of these estimates are that the area of birch woodland was 131.10 kha at the time of the initial survey in 1987-1991. Earlier analyses of the 1987-1991 survey did result in 115.40 kha (Traustason & Snorrason 2008). The difference is the area of woodland that was missed in the earlier survey. Current area of natural birch woodland is estimated to 146.32 kha. The difference of 15.22 kha is an estimate of a natural expansion of the woodland over the time period of 1987 to 2011 (24 years). In the plot measurements 2005-2011 the ratio of the natural birch woodland that can reach 2 m height in mature state and is defined a forest was 65% of the total area. Natural birch forest is accordingly estimated 85.58 kha in 1987 and 95.51 kha in 2011, the former figure categorising the natural birch forest classified as Forest remaining Forest and the differences between the two figures (9.94kha) as natural birch forest classified as Grassland converted to forest land with mean annual increase in of 0.41 kha.

In a chronosequence study (named ICEWOODS research project) where afforestation sites 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 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 50 years (see also Chapter 7.12.1.3). Conversion period for land use changes to "Forest land" from "Other land" is also assumed to be 50 years.

The area of cultivated forest in 2011 is estimated in NFI as 37.92 kha (±1.62 kha 95% CL) whereof; 28.83 kha (±1.68 kha 95% CL) are Afforestation 1-50 years old on "Grassland converted to Forest land", 0.85 kha (±0.40 kha 95% CL) are Afforestation 1-50 years old on "Cropland converted to Forest land", 6.55 kha (±1.06 kha 95% CL) are Afforestation 1-50 years old on "Other Land converted to Forest land", 1.01 kha (±0.44 kha 95% CL) are Plantations in natural birch forests and 0.69 (±0.37 kha 95% CL) are Afforestation older than 50 years.

The total area of Forest land other than “Natural birch forest” was revised on basis of new data obtained in NFI sample plot measurements from the year of 2012. In 2012 submission this area was estimated 36.16 kha (±1.65 kha 95% CL) in 2010 but in this year’s submission the estimate for 2010 is 36.11 kha (±1.65 kha 95% CL) reflecting the effect of the recalculation.

The area of Forest land on organic soil was also revised according to new data from NFI. The area of organic soil in the cultivated forest was for the inventory year 2010 reported 3.38 kha (±0.79 kha 95% CL) in 2012 submission but is estimated 3.28 kha (±0.78 kha 95% CL) for 2010 in this year’s submission reflecting the recalculation.

Aggregated category of all Afforestation and category of Natural Birch Forest are both recognized as key sources/sinks in level (2010) and in trend.

The area of the cultivated forest used in land use class Forest Land in the CRF is based on the NFI sample plot measurements is updated with new field measurements annually. Maps provided by IFR shows larger area of cultivated forests than the NFI sample plot estimate. Map of cultivated forest cover is built on an aggregation of maps used in forest management plans and reports that is revised with new activity data annually. This overestimation of the area of cultivated forest on these maps is known (Traustason and Snorrason 2008) but the differences between these two approaches get lesser and lesser every year as the quality of the maps source increases.

The smaller 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 7.3.9.

7.5.1 Carbon Stock Changes (5A)

Changes in C-stock of natural birch forest are reported for the third time in this year’s submission. As mentioned before they are totally revised in this submission. In 1987 a tree data sampling was conducted to i.a. estimate the biomass of the natural birch woodland in Iceland (Jónsson 2004). These data have now been used to estimate the woody C-stock of the natural birch woodland in 1987 (Snorrason et al. 2013) The new estimate take into account treeless areas inside the woodland that are measured to be 35% for shrubland (under 2 m at maturity) and 19% for forest in the sample plot inventory of 2005-2011. The new estimate is built on same newly made biomass equations as used to estimate current C-stock. Total biomass of birch trees and shrubs in natural birch woodlands was according to the new estimates 976 kt C (±586 kt 95% CL) with average of 7.44 t C ha^{-1} in 1987. A rough older estimate from same raw data was only for biomass above ground 1300 kt C with average of 11 t C ha^{-1} (Sigurðsson and Snorrason 2000). A new estimate of the current C-stock of the natural birch woodland built on the sample plot inventory of 2005-2011 is 1064 kt C (±298 kt 95% CL) with average of 8.11 t C ha^{-1}. The C-stock in the forest and the shrub part of the natural birch woodland is estimated to 832 kt C with an average of 9.72 t C ha^{-1} and 232 kt C with average of 5.10 t C ha^{-1}.

Carbon Stock Changes in Living Biomass

Carbon stock gain of the living biomass of trees in the cultivated forest is estimated based on data from direct sample plot field measurement of the NFI. The figures provided by IFR are based on the inventory data from the first national forest inventory conducted in 2005-2009 (Snorrason 2010). In 2010 the second inventory of cultivated forest started with re-measurement of plots measured in 2005 and of new plots since 2005 on new afforestation areas. In 2011 and 2012 same procedure was taken for the 2006 and 2007 plots. In each inventory year the internal annual growth rate of all currently living trees is estimated by estimating the differences between current biomass and the biomass five years ago. Trees that die or are cut and removed in this 5 years period are not included so the C-stock gain estimated is not a gross gain.

Carbon stock losses in the living woody biomass are estimated based on two sources:

1. Annual wood removal is reported as C-stock losses using data on activity statistics of commercial round-wood and wood-products production from domestic thinning of forest (Gunnarsson 2010; Gunnarsson 2011; Gunnarsson 2012). Most of the cultivated forests in Iceland are relatively young, only 17% of it is older than 20 years, and clear cutting has not started. Commercial thinning is taking place in some of the oldest forests and is accounted for as losses in C-stock in living biomass. A very restricted traditional selective cutting is practiced in few natural birch forests managed by the Iceland Forest Service. The volume of the wood from the natural birch forest cannot be distinguished from reported annual volume of cultivated forest.
2. Dead wood measurements on sample plots. (See description of dead wood definition and measurements in next chapter: Net Carbon Stock Changes in Dead Organic Matter). Dead wood measured is reported as C-stock losses in the assessed year of death.

In the natural birch forest only a net C-stock change in living biomass of the trees is estimated:

1. In the natural birch forest, classified as Forest remaining Forest: by comparing biomass stock of the trees in two different times and use mean annual change as an estimate for the annual change in the C- stock. This method is in accordance to Equation 3.1.2 in GPG for LULUCF (page 3.16).
2. In the natural birch forest expansion since 1987: by using a linear regression between biomass per area unit in trees on measurement plots in natural birch woodland and measured age of sample trees ($N=147$, $P < 0.0001$) to measure net annual C-stock change.

In both cases all losses are included in the estimate of the net C-stock change.

In the already mentioned ICEWOODS research project, the carbon stock in other vegetation than trees did show a very low increase 50 years after afforestation by the most commonly used tree species, Siberian larch, although the variation inside this period was considerable. Carbon stock samples of other vegetation than trees are collected on field plots under the field measurement in NFI. Estimate of carbon stock changes in other vegetation than trees will be available from NFI data when sampling plots will be revisited in the second inventory and the samples will be analysed.

Net Carbon Stock Changes in Dead Organic Matter

As for other vegetation than trees, carbon stock samples of litter are collected on field plots under the field measurement in the NFI. Estimate of carbon stock changes in dead organic matter will be available from the NFI data when sampling plots have been revisited in the second inventory and samples analysed.

In the meantime, results from two separate researches of carbon stock change are used to estimate carbon stock change in litter. (Snorrason et al. 2000; Snorrason et al. 2003; Sigurdsson et al. 2005). In the ICEWOOD research project carbon removal in form of woody debris and dead twigs was estimated to 0.083 t C $ha^{-1}yr^{-1}$. Snorrason et al (2003 and 2000) found significant increase in carbon stock of the whole litter layer (woody debris, twigs and fine litter) for afforestation of various species and ages ranging from 32 to 54 year. The range of the increase was 0.087-1.213 t C $ha^{-1}yr^{-1}$ with the maximum value in the only thinned forest measured resulting in rapid increase of the carbon stock of the forest floor. A weighted average for these measurements was 0.199 t C $ha^{-1}yr^{-1}$.

Dead wood is measured on the field plot of the NFI and reported for the first time in this year submission. Current occurrence of dead wood that meet the definition of dead wood (>10 cm in diameter and >1 m length) on the field plot is rare but with increased cutting activity carbon pool of dead wood will probably increase. Measured dead wood is reported as a C-stock gain on the year of death. As occurrence of dead wood on measurements plot is rare, reporting of dead wood is not occurring every year. With re-measurements of the permanent plot it will be possible to estimate the Carbon stock changes in this pool from one time to another as the dead wood will be composed and in the end disappear.

Net carbon Stock Change in Soils

Drained organic soil is reported as a source of C-emission. In this year's submission forest on drained organic soil is reported in the category "Grassland converted to Forest Land - Afforestation 1-50 years old", "Cropland converted to Forest Land-Afforestation 1-50 years old", "Forest Land remaining Forest Land" – subcategory "Afforestation older than 50 years" and subcategory "Natural birch forest". Drained organic soil has not been estimated on "Grassland converted to Forest Land - Natural birch forest expansion. Drained organic soil is not occurring in other categories reported.

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 Grassland and Cropland converted to Forest Land.

Research results of carbon stock changes in soil on revegetated and afforested areas show mean annual increase of soil C-stock between 0.4 to 0.9 t C ha^{-1} yr^{-1} up to 65 years after afforestation. A comparison of 16 years old plantation on poorly vegetated area to a similar open land gave an annual increase of C-SOM of 0.9 t C ha^{-1} (Snorrason et al. 2003). New experimental research result show removal of 0.4 to 0.65 t C ha^{-1} yr^{-1} to soil seven year after revegetation and afforestation on poorly vegetated land (Arnalds et al. 2013). Another chronosequence research with native birch did show a mean annual removal of 0.466 t C ha^{-1} to soil up to 65 years after afforestation of desertified areas (Kolka-Jónsson 2011). All these findings highly support the use of a country specific removal factor of the dimension 0.51 t C ha^{-1} yr^{-1} which is same removal factor as used for revegetation activities.

7.5.2 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 and in Natural birch forest expansion is not occurring. The reported use of N fertilizers is based on data collected by IFR from the Icelandic forestry sector. N_2O emissions from drainage of organic soils are also reported separately for forest land. Due to the structure of the CRF-Reporter the N_2O emission associated with drained soils in forest is reported under the category “Forest land remaining Forest land-5(II)-Organic soil-Afforestation 1-50 years old” although the subcategory “Afforestation 1-50 years old” is categorized under Land converted to Forest Land in the inventory.

7.5.3 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 “Grassland”, “Cropland” and “Other Land”. Small part of the land converted to Forest land is converted from Wetland, but this land is included as Grassland converted to Forest land as data for separating these categorise is unavailable.

7.5.4 Methodological Issues

One of the main data sources of the NFI is a systematic sampling consisting of a total of nearly 1000 permanent plots for field measurement and data sampling. One fifth of the plots are visited and measured each year. Same plots are revisited at 5 year intervals for the cultivated forest and at ten years intervals for the natural birch forest. Currently the sample is used to estimate both the division of area to subcategories and C-stock changes over time for the cultivated forest and the current C-stock of the natural birch forest as already described in Chapter 7.5.1 (Snorrason and Kjartansson 2004; Snorrason 2010). 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 started 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 and the three first years of the second inventory. 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 private cultivated forests. 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.

Historical area of cultivated forest is estimated by the age distribution of the forest in the sample.

The biomass stock change estimates of the C-stock of cultivated forest are for each year built on five years sample plot measurements (Table 7.9). The most accurate estimates are for 2007- 2010 as they are built on growth measurement of; two nearest years before, two nearest years after and of the year of interest (here named midvalue estimates). In these cases biomass growth rate is equally forwarded and backwarded. For the year 2011 the estimated is forwarded one year compared to the midvalue for 2010. As relative growth rate decreases with age the 2011 estimate is an overestimate and was calibrated by 0.95, which is the relative difference between the midvalue and a forwarded value of one year for the year of 2010. Estimates for the year 2005 and 2006 are backwarded values for two and one year accordingly, from the midvalue for the field measurements of the period 2005-2009. They are calibrated with the relative difference between forwarded value and the midvalue of the year 2008 which is 1.21. For later years (1990-2005) a species specific growth model that is calibrated towards the inventory results is used to estimate annual stock changes. In this year's submission C-stock change estimates of biomass built on historical measurement series are used and reported for the first time.

Table 7.9. Measurement years used to estimate different annual estimates of biomass stock change.

Mid value estimates	For-warded estimates	Back-warded estimates	Built on measure-ment years
	2011		2008-2012
2010			2008-2012
2009			2007-2011
2008			2006-2010
2007			2005-2009
		2006	2005-2009
		2005	2005-2009

Changes in the area of natural birch forest is estimated by comparing estimated area in old surveys with estimated area in on-going remapping (Snorrason et al. 2013). As no historical data before 1987 does exist, a time series for changes in area and C-stock of natural birch forest only exist after 1987. They are built on interpolation between 1987 and 2007 and extrapolations from 2007 with even annual increase in area and C-stock.

A mean annual change in the area of the natural birch forest was estimated to 0.414 kha increase between 1987 and 2011.

As for the area, the biomass stock change estimates of the C-stock of natural birch forest are built on comparison of an estimate of historical biomass stock in the year of 1987 using a stock sampling inventory conducted in 1987 and the NFI inventory of 2005-2011. The difference between these inventories shows a slight increase in biomass C-stock between

1987 and 2007. Same increase rate is used for 2008-2011. The method used only gives a mean net annual C-stock change in the period 1990-2011, not gains and losses.

7.5.5 Emission/Removal Factors

Tier 3 approaches is used to estimate the carbon stock change in living biomass of the trees in both cultivated forest and the natural birch forest through the data from NFI and older surveys.

The losses reported in living biomass removed as wood are estimated by Tier 3 on basis of activity data of annual wood utilization from Icelandic forest (Gunnarsson 2012).

Carbon stock change in living biomass in other vegetation than trees is not estimated currently. In-country research results (Sigurdsson et al. 2005) did show small or no changes of carbon stocks in these sources.

Tier 2, country specific factors are used to estimate annual increase in carbon stock in mineral soil and litter. 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, 0.51 t C ha^{-1} yr^{-1}. Revegetation and afforestation on devegetated soil are very similar processes, except that in the latter includes tree-planting. A removal factor of 0,141 Mg C ha^{-1} yr^{-1} which is an nominal average of two separate research (Snorrason et al. 2000; Snorrason et al. 2003; Sigurdsson et al. 2005) is used to estimate increase in carbon stock in the litter layer.

Tier 3 approach is used to estimate changes in dead wood stock. As already described dead wood meeting the minimum criteria of 10 cm in diameter and 1 m in length is measured in the field sample plot inventory. Decay class and initation year are also assessed. Dead wood is then reported in the dead wood stock at the initation year. The changes in litter and dead wood stock are reported together as changes in dead organic matter stock.

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.

In accordance to the Forest Law in Iceland the State Forest Service holds a register on planned activity that can lead to deforestation (Skógrækt ríkisins 2008).Deforestation activities have to be announced to the State Forest Service. IFR has sampled activity data of the affected areas and data about the forest that has been removed. This data is used to estimate emissions from the lost biomass. Deforestation is reported for the inventory years 2004-2007 and for 2011. Two rather different types of deforestation have occurred in these years. The first and most common type is road building, house building and construction of snow avalanche defences. This type is occurring in all years mentioned. In these cases not only the trees were removed but also the litter and dead wood together with the uppermost soil layer. These afforestation areas were relatively young (around 10 years from initation) so dead wood did not occur. According to the 2006 IPCC Guidelines Tier 1 method for dead organic matter of Forest Land converted to settlements (Vol. 4-2, chapter 8.3.2), all carbon contained in litter is assumed to be lost during conversion and subsequent accumulation not accounted for. Carbon stock in litter has been measured outside of forest areas as control data in measuring the change in the C-stock with afforestation. Its value varies depending on the situation of the vegetation cover. On treeless medium to fertile sites a mean litter C stock of 1.04 ton ha^{-1} was measured (n=40, SE=0.15; data from research described in Snorrason et al., 2002). Given the annual increase of 0.141 ton C ha^{-1} as used in this year submission, the estimated C stock in litter of afforested areas of 10 years of age on medium to fertile land is 2.45 ton C ha^{-1}. Treeless, poorly vegetated land has a much sparser litter layer. Data from the research cited above showed a C-stock of 0.10 ton ha^{-1} (n=5, SE: 0.03). A litter C-stock of a 10 year old afforestation site would be 1.51 ton C ha^{-1}. Using the same ratio between poor and fully vegetated land as in this year submission, i.e. 17% and 83%, accordingly, will give 2.29 tonnes C ha^{-1} as weighted C-stock of 10 year old afforestations. As with carbon in litter, soil organic carbon (SOC) has been measured in research projects. SOC in the same research plots that were mentioned above for poorly vegetated areas was 14.9 tonnes C ha^{-1}, for fully vegetated areas with thick developed andisol layers it was 72.9 tonnes C ha^{-1} (n=40; down to 30 cm soil depth). Annual increase in poor soil according to this year submission is 0.513 ton C ha^{-1} yr^{-1} for poorly vegetated sites and 0.365 ton C ha^{-1} yr^{-1} for fully vegetated sites. Accordingly, ten year old forests will then have a C-stock of 20 and 76.6 tonnes ha^{-1} on poor and fully vegetated sites, respectively. Weighted C-stock of treeless land is then 66.9 tonnes ha^{-1}. According to the 2006 IPCC guidelines Tier 1 method for mineral soil stock change of land converted to Settlements, land that is paved over is attributed a soil stock change factor of 0.8. Using a 20 year conversion period this means an estimated carbon stock loss of 1% during the year of conversion, i.e. the annual emission from SOC will be 0.67 ton C ha^{-1}. These factors were used to estimate emission from litter and soil in this first type of deforestation.

The second type of deforestation is one event in 2006 were trees in an afforested area were cut down for a new power line. Bigger trees were removed. In this case litter and soil is not removed so only the biomass of the trees is supposed to cause emissions instantly on the year of the action taken and reported as such.

7.5.6 Uncertainties and QA/QC

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

The NFI and the special inventory of deforestation have greatly improved the quality of the carbon stock change estimates. The same can be stated in the case of new approach to estimate the net change of C-stock in biomass of the natural birch woodland. By comparing two national estimates from two different times, errors caused by the difficulty of estimating natural mortality are eliminated.

Because of the design of the NFI it is possible to estimate realistic uncertainties by calculating statistical error of the estimates. Error estimate for all data sources and calculation processes has currently not been conducted but are planned in the near future.

Currently, error estimate are available for the area of cultivated forest, and the biomass C-stock of of the natural birch woodland in two different times as already stated (See page 164 and 166). As the sample in the cultivated forest is much bigger than the sample in the natural birch woodland (769 plots compared to 210 plots in the natural birch woodland) one should expect a relative lower statistical error of the biomass C-stock of cultivated forest then for the natural birch woodland.

7.5.7 Recalculations

As described above the emission/removal estimate for forest land has been revised to a great extent in comparison to 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 and new approaches used. For the first time a time series built on direct stock measurement is calculated and reported for cultivated forest. Estimates for the natural birch forest are totally revised. As result of these recalculations the total reported removal has decreased from -271.53 Gg CO_2-equivalents for the year 2010 as reported in 2012 submission to -250.53 Gg CO_2-equivalents in this year's submission or a 7.7% decrease in removal. These changes in reported emission removal of the category reflect the improvement in data and estimation of factors previously not estimated as well as development in the methodology applied for estimating this category.

7.5.8 Planned Improvements regarding Forest Land

Data from NFI are used for the fifth time to estimate main sources of carbon stock changes in the cultivated forest where changes in carbon stock are most rapid.

Sampling of soil, litter, and other vegetation than trees, is included as part of NFI 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.

New mapping of the natural birch woodland which started the summer 2010 will continue. That will increase the accuracy of the new area estimate of the natural birch woodland and the changes in area with time.

New and better single stem biomass equations for birch that were published (Snorrason et al. 2013) and used in the estimate of the biomass changes in the natural birch woodland will also be used in next year submission to calculate biomass and biomass changes in birch in the cultivated forest.

One can therefore expect gradually improved estimates of carbon stock and carbon stock changes regarding forest and forestry in Iceland. As mentioned before improvements in forest inventories will also improve uncertainty estimates both on area and stock changes.

7.6 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.

Carbon dioxide emissions from “Cropland remaining Cropland” and “Land converted to Cropland” are both recognized as key source/sink.

Mapping of cropland based on satellite images and with the support of aerial photographs has been included in the construction of IGLUD. Previous mapping of Cropland was revised in 2009 by the AUI through on screen digitations. The total area of Cropland mapping unit in IGLUD, taking into account the order of compilation applied, is estimated at 169.69 kha. The area reported in CRF is 129.94 kha, where of 58.08 kha are estimated as organic soil. The reported area is a product of the primary time series for new cultivation, drainage of wetland for cultivation, and Cropland abandonment. The time series are prepared by AUI from agricultural statistics, available reports and unpublished data. The preparation of time series will be described in detail elsewhere. These time series are shown in Figure 7.5.

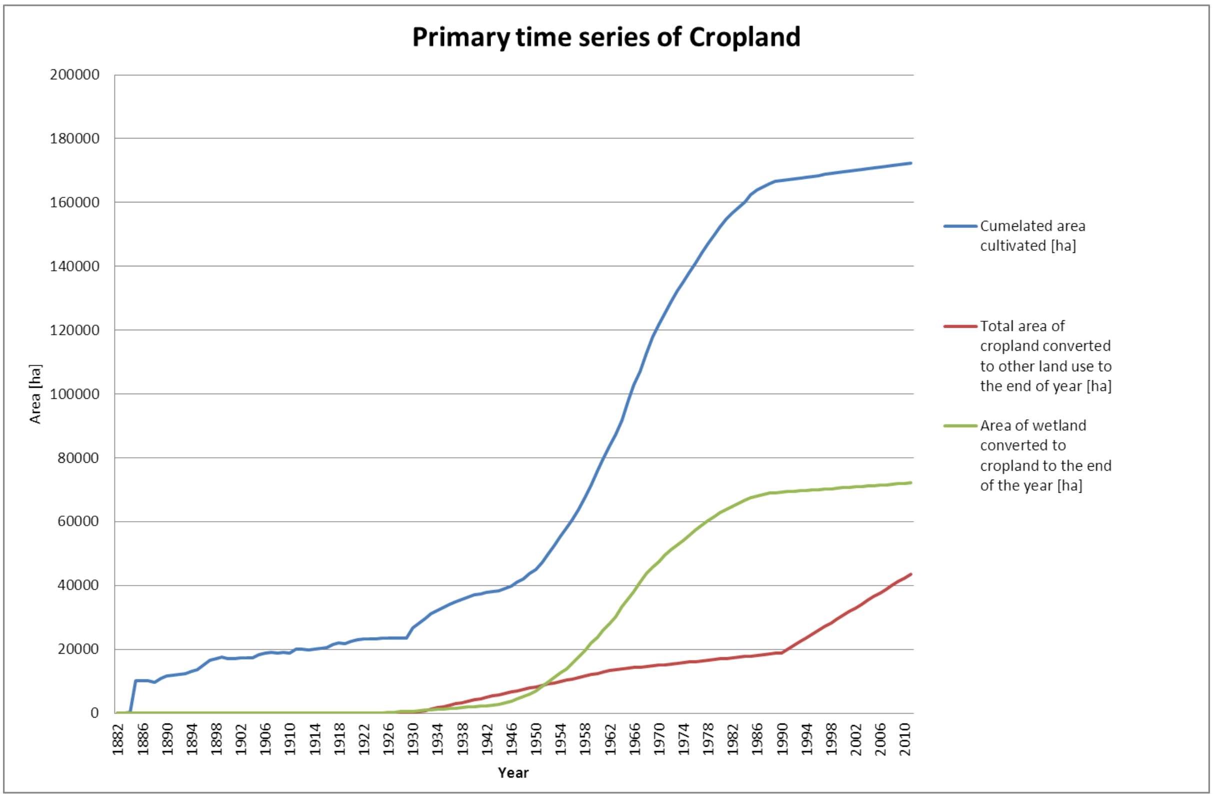

Figure 7.5. Primary time series of Cropland area: Cumulated area represents all land that has been cultivated to that time. Area of wetland converted to cropland represents the part of that area on organic soil. Total area converted to other land use represents the estimated area of abandoned Cropland.

From these primary time series, secondary times series of Cropland remaining Cropland, total area and area on organic soil, Grassland converted to Cropland and Wetland converted to Cropland are calculated (Figure 7.6).

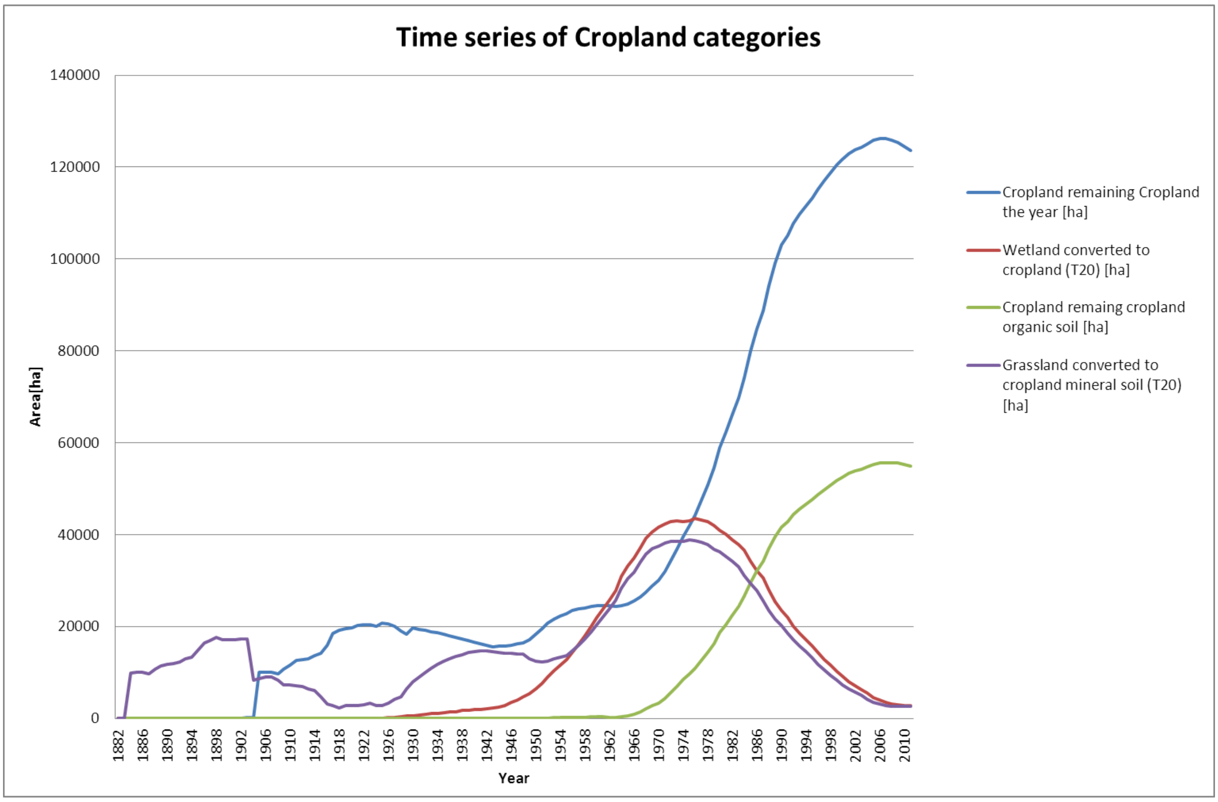

Figure 7.6. Time series of Cropland as reported. Area in hectares as estimated at the end of the year.

The area of Cropland organic soils is estimated through the time series available as described above (ch. 7.3.7). The geographical identification of Cropland organic soils needs to be improved.

No information is available on emission/removal regarding different cultivation types and subdivision of areas according to the types of crops cultivated is not attempted.

7.6.1 Carbon Stock Change (5B)

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. Time series for land converted to Cropland applied in last year's submission are extended to the present inventory year. Changes in living biomass in connection with conversion of land to Cropland are, according to the 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. Changes in living biomass of land converted to Cropland are in this year's submission estimated for both losses and gains. Losses are estimated for the area converted in the year. The biomass prior to conversion is estimated from preliminary results from IGLUD field sampling (Gudmundsson et al. 2010). Based on that sampling the above ground biomass, including litter and standing dead, for Grassland below 200 m height a.s.l. is 1.27 kg C m^{-2}, and for Wetland below 200m 1.80 kg C m^{-2}. The losses in biomass following conversion of land to Cropland are estimated 4.06 Gg C, where of 1.61 Gg C is from Grassland converted and 2.45 Gg C from Wetland converted. The

CO_2 emission is thus 14.89, 5.90 and 8.98 Gg CO_2 respectively. Gains are estimated for the area converted to Cropland the year before assuming biomass after one year of growth to be 2.1 t C ha^{-1}. The total gain in biomass for land converted to Cropland is thus estimated as 0.55 Gg C, with 0.27 Gg C from Grassland converted and 0.29 Gg C from Wetland converted. The CO_2 removal of the gain is 2.01, 0.99, and 1.06 Gg CO_2 respectively. The net loss is 3.51 Gg C for all land converted or emission of 12.87 Gg CO_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 that no emission/removal factors or activity data are needed. No data is available to estimate the possible changes in dead organic matter in cropland 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. Changes in DOM in the year of conversion and in the first year of growth after conversion are included in the changes estimated for living biomass.

Net Carbon Stock Change in Soils

Net carbon stock changes in mineral cropland soil for the category “Grassland converted to Cropland” are estimated according to Tier 1 method. Most croplands in Iceland are hayfields with perennial grasses, which are harvested once or twice during the growing season. Ploughing or harrowing is only done occasionally (10 years interval). Many of hayfields are also used for livestock grazing for part of the growing season (spring and autumn in case of sheep farming). Most hayfields are fertilized with both synthetic fertilizers and manure. Changes in SOC for mineral soil are calculated according to T1 using equation 2.25 in 2006 IPPC guidelines. Default relative stock change factors considered applicable to hayfields with perennial grasses were selected from Table 5.5 in 2006 IPCC guidelines (IPCC 2006). For Land use the “set aside-dry” F_{LU} = 0.93 was selected based on the descriptions in Table 5.5 best describing the hayfields in Iceland. For management and input, F_{MG} =1.10 no tillage-temperate boreal -dry and F_I =1.00 medium input, were selected. The SOC_{REF}, 90.5 tC ha^{-1}, is the average SOC (0-30 cm) from IGLUD field sampling for Grassland (AUI unpublished data). The initial mineral soil organic C stock is accordingly SOC_0 = 90.5 t C ha^{-1} * 0.93*1.10*1.00 = 92.6 t C ha^{-1}. For the 20 year conversion period the annual change in $\Delta C_{Mineral}$ = 0.10 t C ha^{-1} for Grassland converted to Cropland. No mineral soil is assumed under Wetland converted to Cropland. Changes in C-stock of mineral soils under “Cropland remaining Cropland” are not estimated as no information on changes in management is available.

Changes in SOC of organic soils are calculated according to T1 applying equation 2.26 in 2006 IPCC guidelines (IPCC 2006). All soils of Wetland converted to Cropland are assumed organic.

7.6.2 Other Emissions (5(I), 5 (II), 5(III), 5(IV))

Direct N_2O emissions from use of N fertilisers are included under emissions from agricultural soils and reported under 4.D.1.

All N_2O emissions from drainage of organic soils are reported under the Agriculture sector 4.D.1.5- Cultivation of Histosols. N_2O emissions from disturbance associated with conversion of land to cropland (5.(III)) are included there as indicated by use of the notation key IE.

Carbon dioxide emissions from agricultural lime application are estimated. Information on lime application was 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. The CRF- Reporter only allows Cropland liming to be reported under Cropland remaining Cropland. The bulk of the liming on Cropland in Iceland can be assumed to be on organic soil as pH of mineral soils is generally so high that liming is unnecessary.

7.6.3 Land converted to Cropland

The conversion of land to Cropland is reported in two categories. It is thus assumed that all mineral Cropland originate from Grassland and Cropland on organic soil originates directly from Wetland. Some of the Cropland on organic soils may have been drained Grassland for some period before converted to Cropland. Also some areas of Cropland on mineral soil may have originated from other land use categories such as “Other land” or “Forest land” (Natural birch forests). There is presently no data available for the separation of conversion into more categories and until then all conversions are reported as aggregates area under the two categories. The default conversion period 20 years is applied for Grassland converted to Cropland and Wetland converted to Cropland.

Land converted to Cropland is recognized as a key source/sink including LULUCF.

7.6.4 Emission Factors

The CO_2 emissions from Cropland organic soil calculated according to a Tier 1 methodology using the EF= 5.0 t C $ha^{-1}yr^{-1}$ (AFOLU Guidelines Table 5.6).

The emissions caused by conversion of land to Cropland is calculated on the basis of country specific estimate of C stock in living biomass, litter and standing dead biomass 1.27 ± 0.24 kg C m^{-2} and 1.80 ± 0.51 kg C m^{-2} for Grassland and Wetland respectively as estimated from field sampling. Methods are described in (Gudmundsson et al. 2010). The Cropland biomass after one year of growth is 2.1 t C ha^{-1} from Table 5.9 in 2006 IPCC guidelines (IPCC 2006). The SOC_{Ref} = 90.5 ±28.2 t C ha^{-1}, for mineral soils of Grassland converted to Cropland is country specific and based on IGLUD soil sampling preliminary results. For the 20 year conversion period the annual change in $\Delta C_{Mineral}$ = 0.10 t C ha^{-1} for Grassland converted to Cropland.

The CO_2 emissions due to liming of cropland are calculated by conversion of carbonated carbon to CO_2.

7.6.5 Uncertainty and QA/QC

According to the time series for Cropland the cumulated area of cultivated land is in reasonable good agreement with the area mapped as Cropland 172 kha versus 169 kha. Abandoned cropland is included in both estimates.

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). A survey of cropland was initiated the summer 2010 to control the IGLUD mapping of cropland. Randomly selected 500*500m squares below 200 m a.s.l. were visited and the mapping of cropland inside these squares was controlled. Total number of squares visited was 383 with total area 9187 ha including mapped cropland of 998 ha. Of this mapped cropland 216 ha or 21% were not confirmed as cropland and 38 ha or 4% were identified as cropland not included in the map layer. Uncertainty in area of Cropland is therefore set as 20%.

The area of drained Cropland is in this year's submission estimated through preparation of time series of land use conversion as described above. The ratio of hayfields on organic soil was estimated in a survey on vegetation in hayfields 1990-1993 (Þorvaldsson 1994) as 44%. The time series of Cropland organic soil were adjusted to that ratio. In the summer 2011 a survey on Cropland soils was carried out as part of the IGLUD project involving systematic sampling on 50x50m grid of randomly selected polygons of the Cropland mapping unit. Preliminary results from this sampling effort show similar ratio of organic soils. The uncertainty for the area of Cropland on organic soil is for this submission assumed 20% or the same as for Cropland total area.

The emission/removal estimated for land converted to Cropland is based on factors estimated with standard error of 20-30%. The uncertainty of the calculated emission removal is accordingly in the same range.

The emissions reported from organic Cropland are based on default EF from AFOLU Guidelines Table 5.6 the uncertainty of that EF is 90%. Emissions due to liming calculated on basis of amounts of liming agents, independent of area.

No quality control or quality assurance has been undertaken regarding the submitted amounts of liming agents.

7.6.6 Recalculations

No recalculations are made for the Cropland category.

7.6.7 Planned Improvements regarding Cropland

In this submission as in last year's submission time series of Cropland categories were used to estimate the area of each category. Further improvements of the mapping and subdivision are still needed as e.g. revealed through the cropland mapping survey described above. The area of land converted to Cropland from other categories than Grassland or Wetland needs to be determined. Continued field controlling of mapping, improved mapping quality and division of cropland soil to soil classes and cultivated crops is planned in coming years. As the introduction of time series revealed that a considerable area of the mapping unit Cropland is abandoned cropland. Identifying the abandoned cropland within the mapping unit is considered of high importance. Information on soil carbon of mineral soil under different management and of different origin is important to be able to obtain a better estimate of the effect of land use on the SOC. Establishing reliable estimate of cropland biomass is also important and is planned in the summer 2013.

Considering that the CO_2 emissions from both “Cropland remaining Cropland” and “Land converted to Cropland” are recognized as key sources, 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 on-going research projects at the AUI. These studies are assumed to result in new emission factors. Data, obtained through fertilization experiments, on carbon content of cultivated soils is available at the AUI. The data is currently being processed and is expected to yield information on changes in carbon content of cultivated soils over time.

7.7 Grassland

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

The land included under the Grassland category is in this submission divided into ten subcategories. One of these subcategories i.e. “Natural birch shrubland recently expanded into Other Grasslands” is for the first time reported. Although this strictly speaking is land use conversion the reporting format does not allow for land use conversions within categories and therefore reported under “Grassland remaining Grassland”. The subcategory “Natural birch shrubland” from last year submission is renamed to “Natural birch shrubland old”.

The Grassland time series reported are prepared from three primary time series (Figure 7.7), and an independent time series for expansion of birch shrubland into other grassland. The time series of Other Grassland is prepared from the Grassland mapping unit when all other mapping units of grassland subcategories have been taken into account representing the area 2010. The backward tracking of area within that category was done by correcting the area of the year after according to all area within other land use categories considered originate from Other Grassland, including Forest land, Cropland, other Grassland subcategories and Reservoirs (Figure 7.8, Figure 7.9, and Figure 7.10).

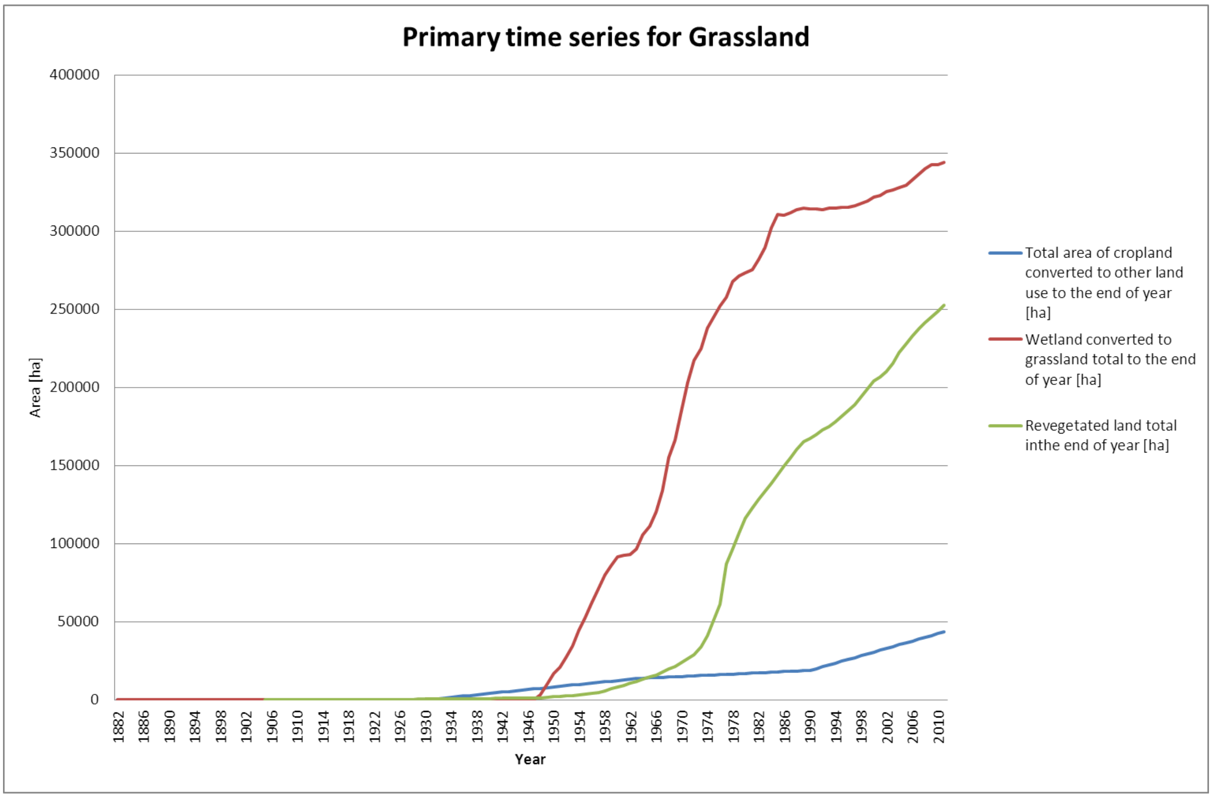

Figure 7.7. Primary time series for Grassland: Total area of Cropland converted to other land uses at the end of the year, Wetland converted to Grassland at the end of the year, Revegetated land at the end of the year. All graphs showing cumulative area at the end of the year from the beginning of time series.

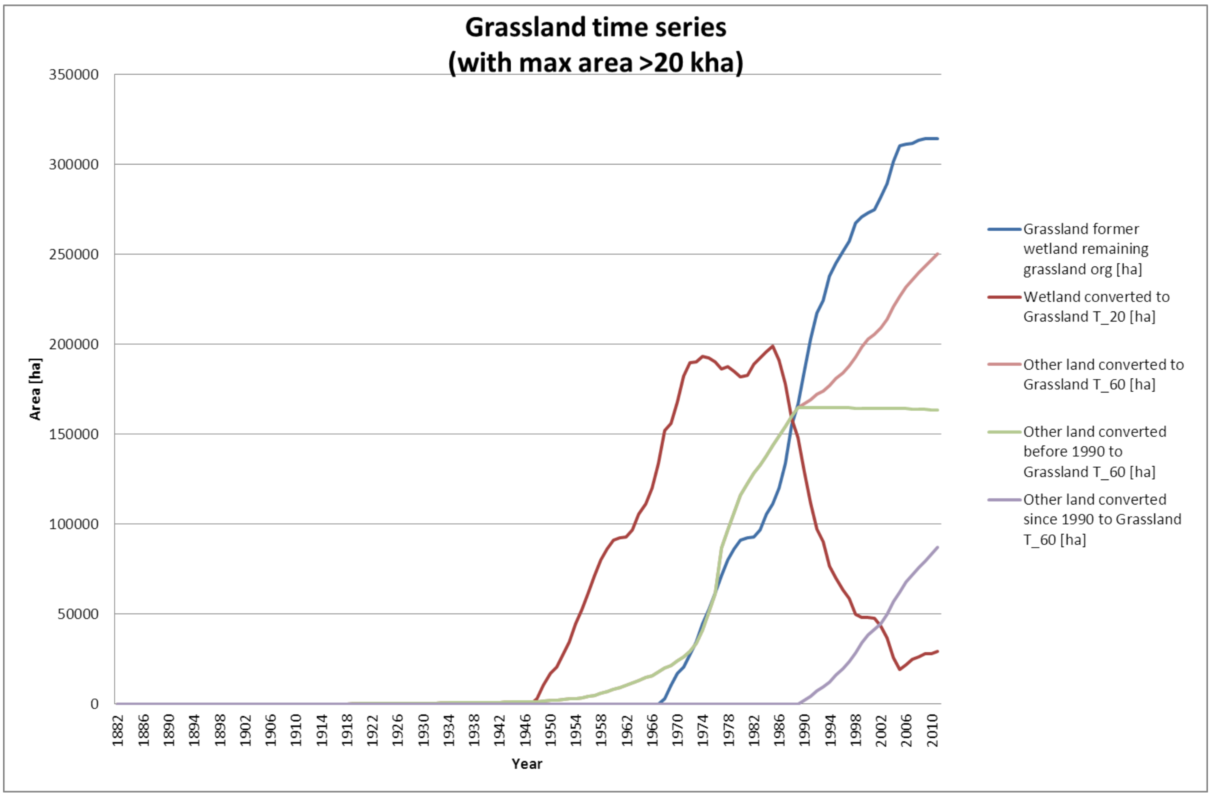

Figure 7.8. Time series of reported Grassland categories with max area >20 kha: Grassland former Wetland remaining Grassland organic soil, Wetland converted to Grassland T_20, Other land converted to Grassland T_60, Other land converted to Grassland before 1990 T_60, Other land converted to Grassland since 1990 T_60. All graphs showing the area in hectares at the end of the year.

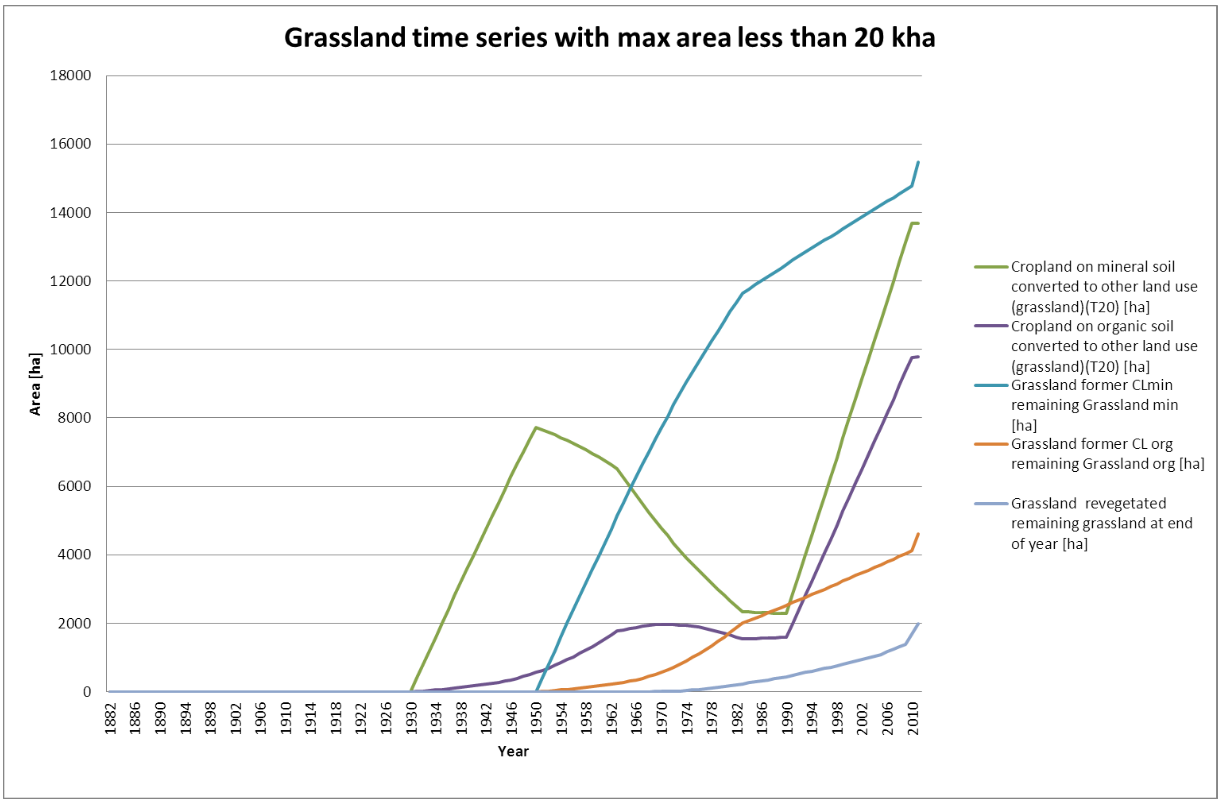

Figure 7.9. Time series of reported Grassland categories with max area <20 kha: Cropland on mineral soil converted to Grassland T_20, Cropland on organic soil converted to Grassland T_20, Grassland former Cropland remaining Grassland mineral soil, Grassland former Cropland remaining Grassland organic soil, Grassland former revegetated Other land remaining Grassland. All graphs showing the area in hectares at the end of the year.

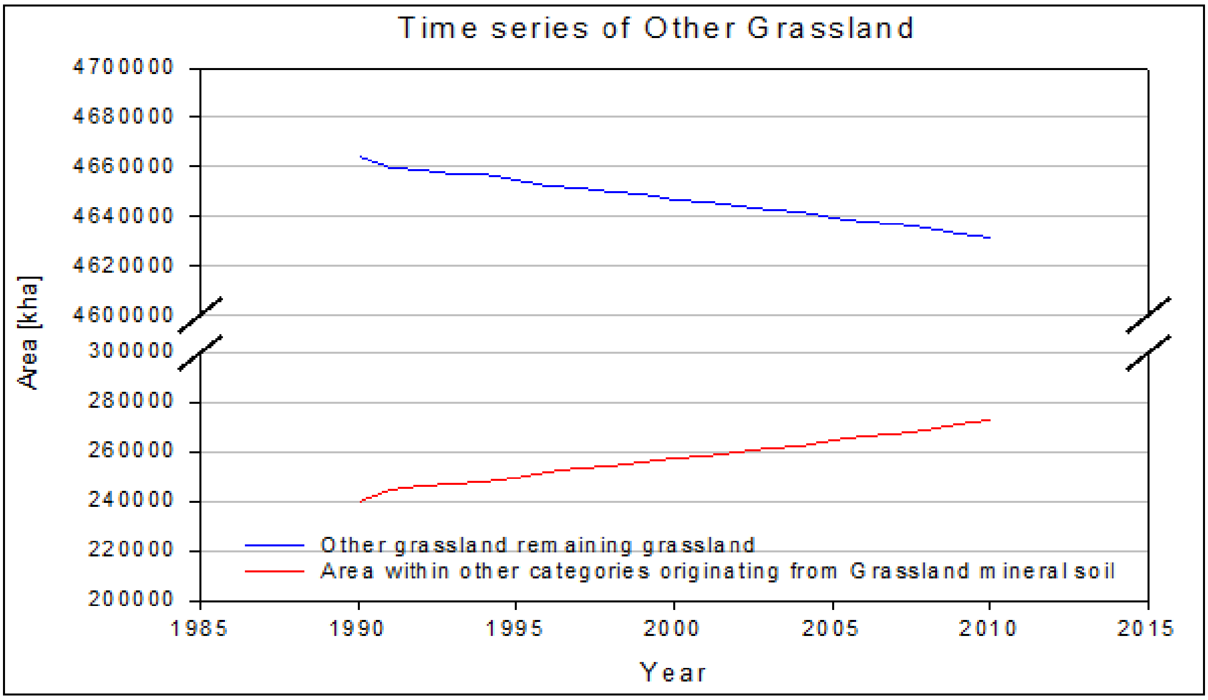

Figure 7.10. Time series for Other Grassland as prepared from changes in area of former Grassland within other land use categories.

7.7.1 Grassland remaining Grassland

The time series and conversion period applied enable keeping track of the area of different origin under the category Grassland remaining Grassland. The subcategories are described below.

Cropland abandoned for more than 20 years.

This category includes all previous cropland abandoned for more than 20 years still remaining under Grassland land use category. The area reported for this category is the area emerging from the time series and estimated as 18.89 kha whereof 4.60 kha is organic soil.

Natural Birch Shrubland

Natural birch shrubland is the part of the natural birch woodland not meeting the thresholds to be accounted for as forest and covered with birch (*Betula pubescens*) to a minimum of 10% in vertical cover and at least 0.5 ha in continuous area. The natural birch shrubland is included in the NFI and is estimated by the IFR. Total area and changes in carbon pools are based on the same methods and data sources as used to estimate the natural birch forest.

Similar to natural birch woodland, two subcategories of natural birch shrubland are reported. One i.e. “Natural birch shrubland –old” is for shrubland remaining shrubland including shrubland surveyed in the 1987 inventory. As for natural birch forest, the C-stock of natural birch shrubland has slightly increased between 1987 and 2007 although the mean annual net change is very low (0.021 Mg C ha^{-1} yr^{-1}). The second subcategory i.e. “Natural birch shrubland – recently expanded into Other Grassland” is for other grassland converted to shrubland. Conversion period is set to 50 years as for natural birch forest and with same in country removal factors for biomass, dead organic matter and mineral soil and IPCC default emission factor for organic soil. As no historical data before 1987 exists, a time series for changes in area and C-stock of natural birch shrubland only exist after 1987. They are built on interpolation between 1987 and 2007 and extrapolations from 2007 with even annual increase in area and C-stock.

Other Grassland

The mapping unit Other grassland includes all land where vascular plant cover is 20% or more as compiled from IGLUD and not included in other Grassland subcategories. Accordingly all land within the land use categories, above Grassland in the hierarchy (Table 7.2), are excluded a priory. The map layers classified as Land converted to grassland are all above map layers included in the category "Other grassland". The land in this category is e.g. heath-lands with dwarf shrubs, small bushes other than birch (*Betula pubescens*), grasses and mosses in variable combinations (respecting the 20% minimum vascular plant cover), fertile grasslands, and partly vegetated land. The area mapped is the adjusted and time series prepared as described above (chapter 7.7 p.172).

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. Recent research indicates that the carbon budget of such areas might be negative, resulting in CO_2 emission to the atmosphere (AUI unpublished data). This land has not been identified in the IGLUD maps, but is likely to be included in this category to a large extent.

Since the settlement of Iceland a large share of the former vegetated areas has been severely eroded and large areas have lost the entire soil mantle. 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 on-going loss of SOC due to erosion is 50-100 kt C yr^{-1} according to the same study. That study only takes in account the soil lost through one type of erosion i.e. erosion escarpments. This loss is comparable to 183-366 Gg CO_2 if all of this lost SOC is decomposed or 92-183 Gg CO_2 if 50% of it is decomposed as argued for in the paper (Óskarsson et al. 2004). This loss is at present not included in the CRF, but the possible amount of C being lost is in the same order of magnitude as CO_2 removal reported as revegetation since 1990 (194 Gg CO_2). The revegetation of deserted areas sequesters carbon back into vegetation and soil and thereby counteracts these losses.

The vegetation cover in many other Grassland areas in Iceland is at present increasing both in vigour and continuity (Magnússon et al. 2006). 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 or improvement is one of the IGLUD objectives as described in (Gudmundsson 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.

Revegetated land older than 60 years

By defining a conversion period of 60 years, for Other land converted to Grassland (Revegetation) which is shorter than the time revegetation of other land has been practiced in Iceland, a small area of revegetated land older than 60 years emerges as category. The total area of the category is in this year's submission 1.99 kha. This area is not at present recognised as separate mapping unit but assumed to be included in the mapping unit Revegetation before 1990, despite limited area of that mapping unit.

Wetland drained for more than 20 years.

This category also appears as result of time series and application of default 20 years conversion period for wetland converted to Grassland. As most of the drained area was drained for at least 20 years the majority of the drained wetlands are now reported under this category. The total area reported in this year's submission is 314.63 kha and all of it assumed to be with organic soils. This category is not at present identified as separate mapping unit, but together with the category Wetland converted to Grassland is presented as the mapping unit Grassland organic soil. The preparation of that mapping unit is described in (7.3.9).

7.7.2 Land converted to Grassland

Land converted to Grassland is reported in three categories i.e.; "Cropland converted to Grassland", "Wetland converted to Grassland" and "Other land converted to Grassland". Conversions of Forest land and Settlement to Grassland are reported as not occurring.

Cropland converted to Grassland

The area reported as emerging from the time series available for Cropland using the default conversion period of 20 years. The category is at present not identified as a specific mapping unit but is included in both the mineral and organic soil part of the Cropland mapping unit. The total area reported for this category is 24.63 kha with 9.48 kha on organic soil.

Wetland converted to Grassland

The area included under this subcategory includes the area drained for the last 20 years prior to the inventory year. The total area reported for this subcategory is 29.16 kha and the whole area assumed to be on organic soil. The area estimate is based on available time series and applies 20 years as the conversion period.

Other Land converted to Grassland

Revegetation

The land reported as "Other land converted to Grassland" is the result of revegetation activity. The original vegetation cover is less than 20% for the vast majority of land where revegetation is started, according to the SCSI. Accordingly, this land does not meet the definition of Grasslands and is all classified as other land being converted to Grassland.

The SCSI was established in 1907. Its main purpose is the prevention of on-going 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 Lyme grass (*Leymus arenarius* L.) and other graminoids. These activities are to a large extent recorded. The emphasis on aerial spreading has decreased since 1990 as other methods, such as increased participation and cooperation with farmers and other groups interested in land reclamation work, have proven more efficient. Methods for the recording of 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 in real time, e.g. spreading of seeds and/or fertilizer. In 2008 almost all activities were recorded simultaneously with GPS-units (Thorsson et al. in prep.).

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 (Thorsson et al. 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 NFI (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.

A conversion period of 60 year has been defined on basis of NIRA data sampling. The length of the conversion period is preliminary as the data remains to be analysed further. The category “Revegetation since 1990” represents activity since 1990 accountable as Kyoto Protocol commitments. The area reported as land revegetated before 1990 is reported as “Revegetation before 1990” and “Revegetated land older than 60 years” the latter as subcategory of Grassland remaining Grassland.

The area of Revegetation since 1990 reported for the year 2011 is 87.09 kha compared to 83.21 kha reported for the year 2010 in last year´submission.

The CO_2 removal of the category “Other land converted to Grassland-(Revegetation)” is recognised as key source/sink including LULUCF.

The area reported as Revegetation before 1990 is calculated from the available time series of revegetation before 1990. The mapping of these areas is still subjected to high uncertainty and only small portion of this land is presented in IGLUD map layer Revegetation before

1990. The area not included in that map layer is assumed to be located within the SCSI's designated areas. Estimation on total revegetation area before 1990 is finished based on best available documentation and is presented here, but mapping has not been finished at this point but will be provided in next year's submission (Thorsson J. personal communication)

7.7.3 Carbon Stock Change (5C)

Carbon stock changes are estimated for all subcategories included both under Grassland remaining Grassland and Land converted to Grassland.

Carbon Stock Change in Living Biomass

The changes in living biomass of the subcategories "Natural birch shrubland–old" and Natural birch shrubland-receently expanded into Other Grassland" are estimated by IFR based on NFI data. The living biomass of these categories is estimated to have increased by 0.96 Gg C and 1.43 Gg C respectively removing 3.52 Gg CO_2 and 5.24 Gg CO_2 from the atmosphere. Carbon stock changes in living biomass of other subcategories of Grassland remaining Grassland i.e. "Revegetation older than 60 years", "Wetland drained for more than 20 years", "Cropland abandoned for more than 20 years", and "Other Grassland" are reported as not occurring based on Tier 1 method for Grassland remaining Grassland.

Carbon stock changes in living biomass are estimated for all categories of Land converted to Grassland where conversion is reported to occur. Conversions of "Forest land" and "Settlements" to Grassland are reported as not occurring. Changes in living biomass in the category Wetland converted to Grassland are reported as not occurring as vegetation is more or less undisturbed, as no ploughing or harrowing takes place. Changes in living biomass in the category Cropland converted to Grassland are estimated on basis of default Cropland biomass (Table 5.9. in 2006 IPCC guidelines (IPCC 2006)) and average C stock in living biomass, litter and standing dead biomass of Grassland as estimated from IGLUD field sampling (see chapter 7.6.4). The living biomass of this category is estimated to have increased by 13.03 Gg C in 2011, consequently removing 47.78 Gg CO_2. "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 (Aradóttir et al. 2000; Arnalds et al. 2000). The total C-stock increase is estimated on basis of NIRA sampling. The carbon stock in living biomass is estimated to have increased by 9.31 Gg C and 4.96 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 34.14 Gg CO_2 and 18.19 Gg CO_2 from the atmosphere, respectively.

Net Carbon Stock Changes in Dead Organic Matter

Changes in carbon stock of dead organic matter are estimated for the category "Natural birch shrubland-recently expanded into Other Grassland" by the IFR in the NFI.

This carbon stock is estimated to have increased by 0.75 Gg C in the year 2011 and accordingly removing 2.75 Gg CO_2 from the atmosphere.

The changes in dead organic matter are included in C-stock changes in living biomass for the category "Cropland converted to Grassland" see above (chapter 7.6.4). The changes in dead organic matter are also included in living biomass of “Other land converted to Grassland” (Aradóttir et al. 2000).

Changes in dead organic matter of “Wetland converted to Grassland” are reported as not occurring consequent with no changes in living biomass.

Net carbon Stock Change in Soils

Changes in the carbon stock of the mineral soil of subcategory “Natural birch shrubland recently expanded to Other Grassland” is estimated as having increased by 1.93 Gg C in the year 2011 and thereby removing a total of 7.08 Gg CO_2 form the atmosphere. Changes in carbon stock in mineral soils of land under other subcategories of Grassland remaining Grassland are reported as not occurring in line with Tier 1 method. The Tier 1 methodology gives by default no changes if land use, management and input (F_{LU}, F_{MG}, and F_I) are unchanged over a period. Changes in mineral soil of Cropland converted to Grassland are reported for the first time in this year’s submission. The changes reported are assumed to be reversed changes estimated for Grassland converted to Cropland (7.6.4). The loss from mineral soils of Cropland converted to Grassland is reported as 1.58 Gg C and consequently emitting 5.79 Gg CO_2. No mineral soil is included as “Wetland converted to Grassland”.

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 83.81 Gg C and 44.68 Gg C respectively for the categories Revegetation before 1990 and Revegetation since 1990 removing 307.03 Gg CO_2 and 163.83 Gg CO_2 from the atmosphere.

Organic soils are reported for the Grassland subcategories “Wetland drained for more than 20 years”, “Cropland abandoned for more than 20 years”, “Wetland converted to Grassland” and “Cropland converted to Grassland”. The carbon stock changes in organic soils of land under Wetland converted to Grassland are estimated applying Tier 1 methodology. 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. The carbon stock in drained organic soils included under the Grassland subcategories is estimated to have decreased by 112.04 Gg C in the inventory year emitting 410.81 Gg CO_2.

7.7.4 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 3.6.2, 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 “*Grassland Non-CO_2 emission-5(II)- Non- CO_2 emission from drainage of soils and wetlands-Organic soils*” (7.11.2).

7.7.5 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). The contribution of changes in carbon stock of living biomass (including dead organic matter) and soil were estimated as 10% and 90% respectively is based on these studies. The SCSI has since 2007 been running National Inventory on Revegetation area (NIRA), including sampling of soil and vegetation. New emission factors for changes in C-stocks are based on analyses of these samples. Based on new data already collected in NIRA the emission/removal factors have now been revised from last year's submission (Thorsson et al. in prep). The new 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 -0.06 and -0.51 t C/ha/yr respectively. All revegetated areas 60 years old or less are assumed to accumulate carbon stock at the same rate in the present submission.

Emissions of CO_2 from organic soil in all categories of Grassland except Cropland converted to Grassland are calculated according to Tier 1 methodology EF= 0.25 [t C ha^{-1} yr^{-1}]. The emission factor applied for organic soil of Cropland converted to Grassland is 2.63 considering both default emission factors for Cropland organic soil and Grassland organic soil.

In recent review paper on GHG emission from organic soils in Nordic countries Maljanen et al (Maljanen et al. 2010) report average emission of 1320 g CO_2 m^{-2} yr^{-1} or 3.6 tC ha^{-1} yr^{-1} for abandoned croplands on organic soils in Scandinavia. Recent measurements in Iceland also show comparable emission factor (Guðmundsson and Óskarsson in prep) Considering the category being a key source it is urgent to move up to higher tier in estimating the emission from the category. EF for N_2O is discussed in chapter 7.18.2.2.

The changes in annual living biomass (including litter and dead organic matter) of Cropland converted to Grassland are estimated from C stock in living biomass, litter and standing dead biomass of Grassland as estimated from IGLUD sampling 1.27 ± 0.24 kg C m^{-2} (12.7 t C ha^{-1}) and default Cropland biomass 2.1 t C ha^{-1} from Table 5.9 in 2006 IPCC guidelines (IPCC 2006). The average annual increase in living biomass including dead organic matter is accordingly estimated as 0.53 t C ha^{-1} yr^{-1} with 20 years conversion period.

Carbon stock changes in mineral soils of the subcategory "Natural birch shrubland–recently expanded into Other Grassland" are estimated applying same EF as for mineral soils of afforested Grassland (Bjarnadóttir 2009)

Carbon stock changes for mineral soil of Cropland converted to Grassland are estimated as the reversal of changes in opposite land use changes i.e. Grassland converted to Cropland (see ch. 7.6.4) EF= -0.10 t C ha^{-1}.

7.7.6 Conversion Periods for Land converted to Grassland.

The conversion period for all categories of “Land converted to Grassland” except “Other land converted to Grassland-Revegetation”, is set as default 20 years. The conversion period of Revegetation is set 60 years, based on NIRA sampling (Thorsson et al. in prep.).

7.7.7 Uncertainty and QA/QC

The uncertainty of area of the categories reported is estimate 20% except for Revegetation where the uncertainty in area is 10% according to SCSI.

Changes in C stock of living biomass and dead organic matter of the category Grassland remaining Grassland are reported as not occurring (Tier 1) except for living biomass of Natural birch shrubland. The CO_2 emissions from mineral soils of Grassland remaining Grassland are also reported as not occurring following Tier 1 assumption of steady stock. The uncertainty introduced by applying Tier 1, is as such not estimated.

Carbon stock changes of living biomass for Natural birch shrubland are estimated by IFR through NFI. That estimate shows that changes are occurring in the living biomass of that category. Comparable changes in other pools of that category are expected until the area reaches a new equilibrium. As no specific actions have been taken to increase the living biomass of that category, the observed changes indicate that this is the result of some general cause e.g. changes in climate or management (grazing pressure). The same components would be likely to act similarly on other categories. Considering the severe erosion in large areas included as Grassland, this category could potentially be a large source. These emissions might be counteracted or even annulated by carbon sequestration in areas where vegetation is recovering from previous degradation (Magnússon et al. 2006).

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 applied EF’s ± 90%. The size of the drained area is in this year’s submission estimated from IGLUD as described above. In the summer 2011 a survey of drained Grassland was initiated. The results of that survey have not yet been analysed, but subsample analyse indicate 20-30% uncertainty of area. Many factors can potentially contribute to the uncertainty of the size of drained area. Among these is the quality of the map of ditches. On-going 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. During the summer 2010 the reliability of the map of ditches was tested. Randomly selected squares of 500*500m were controlled for ditches. Preliminary results show that 91% of the ditches mapped were confirmed and 5% of ditches in the squares were not already mapped. 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 buffer zone put to estimate area of drained land have their own uncertainty, which is transferred to the estimate of the 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 becomes 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 becomes available to maintain the water level. No attempt has been made to evaluate these effects of these factors for drained areas.

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.

Regarding the category “Land converted to Grassland” changes for three categories are reported. The aggregated uncertainty of emission factors other than for revegetation is estimated as 90%. The uncertainty of both areas is currently estimated 30%, but it decreases as real-time GPS methodology is increasingly used (Thorsson et al, in prep). EF in Revegetation is estimated 10%.

7.7.8 Planned Improvements regarding Grassland

Emissions of CO_2 from, “Wetland drained for more than 20 years”, aggregated CO_2 emission from “Other conversions to Grasslands”, “Other land converted to Grassland” are identified as key sources both as level and trend, and N_2O emission of “Grassland non CO2-emissions” as level. The emissions from organic soil within these categories are important source.

Data for dividing the drained area according to soil type drained has been collected for a part of the country. Continuation of that sampling is planned and the results used to subdivide the drained area into soil types. Improvements in ascertaining the extent of drained organic soils in total and within different land use categories and soil types is also a priority. In summer 2011 a project, aiming at improving the geographical identification of drained organic soils, was initiated. This project involved testing of plant index and soil characters as proxies to evaluate the effectiveness of drainage. This project was continued in summer 2012 and it is expected that data sampling will be completed in this year. The results of this project are expected to improve the area estimate of drained land and of effectiveness of drainage. In connection with planned HiRes mapping of some land use categories within the CORINE project, training sets for remote sensing of land use categories, including wetland and different drainage stages, will be identified. This project is expected to give high resolution maps of several land use categories and thereby improving the overall mapping of drained wetlands.

Age of drainage can be important component affecting the emission from the drained soil, the effectiveness of the drainage can also be assumed to depend on drainage age. Therefore geographical identification of drained areas of different age is planned in near future. Such information can also be used to evaluate the time series of drainage.

In this submission a new subcategory is added i.e. “Natural birch shrubland –recently expanded into Other Grassland” Otherwise the subdivision remains unchanged. . The largest subcategory of Grassland, “Other Grassland”, is still reported as one unit. 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 emissions. 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) Subdivision of that category according to management, vegetation condition and soil erosion is pending. That subdivision is expected to make it possible to report changes occurring in some areas (Magnússon et al. 2006).

Carbon stock changes in living biomass and mineral soil of Cropland converted to Grassland were reported for the first time in last submission. It is planned to improve the estimate of the relevant C- stocks behind that reporting.

Improvements in both the sequestration rate estimates and area recording for revegetation, aim at establishing a transparent, verifiable inventory of carbon stock changes 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 and all data will be in acceptable form beginning in 2012. Data on older activities started after 1990 are currently under revision and are planned to be finished this year if manpower allows. 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 on-going. The second improvement is pre-activity sampling to establish a zero-activity baseline for future comparisons of SOC. This has been implemented for all new areas established in 2010 and later (Thorsson et al. in prep.). 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 confirm that areas 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.

7.7.9 Recalculation

The area of Natural birch forest and shrubland has been revised according to NFI new data. The changes in the total area of the two birch categories affect the area estimate of many Grassland subcategories lower in the hierarchical order of mapping units. The C-stocks of the Natural birch shrubland subcategories were revised according to new data and changes in area estimates.

A typing mistake in calculations for last submission regarding EF for organic soil under “Cropland converted to Grassland” was corrected and the EF changed from 2.38 to 2.68 [t C ha^{-1} yr^{-1}].

All other recalculations are because of changes in area traced to remapping of birch forest and shrubland.

7.8 Wetland

The area of the category “Lakes and rivers” is changed as consequence of increased area of natural birch forest decreased from 260.04 kha reported last year to 259.99 kha reported this year. The mapping layer “Natural birch forest >2m” is above “Lakes and rivers” mapping layers in the hierarchy of layers used in the map layer compilation and the resolution in the mapping of birch forest is less than in the maps of lakes and rivers. The area of the category “Other wetland” reported in this submission is 396.62 kha compared to 398.01 kha reported in last submission. The decrease in area of 1.39 kha is explained by as new drainage.

Emissions are only estimated for the categories Grassland and Other land converted to wetland resulting from flooding of land due to establishment of hydropower reservoirs. The emission estimates for this category has not changed from last year’s submission.

7.8.1 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, and noted in the CRF as not applicable. 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 7.9.1).

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.

Flooded Land

CO_2 emission from reservoirs is presented for three subcategories:

- Grassland with high soil organic carbon content (High SOC). SOC higher than 50 kg C m^{-2}. 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.

- Grassland with medium soil organic content (Medium SOC). SOC 5-50 kg C m^{-2}. This land includes most grassland, cropland and forestland soils except the drained wetland soils.

- Other land with low soil organic content (Low SOC). SOC less than 5 kg C m^{-2}. This category includes land with barren soils or sparsely vegetated areas previously categorized under “Other land”.

The emissions 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). For the three new reservoirs established 2009 and one established 2007 new reservoir specific emission factors were calculated according to (Óskarsson and Guðmundsson 2008) from the estimated amount of inundated carbon. The inundated carbon of these reservoirs was estimated by (Óskarsson and Guðmundsson 2001) and (Óskarsson and Gudmundsson in prep). Reservoir classification is based on information, from the 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 the ice-free period. Limited data is available on ice-free periods 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 in the inventory year 2010 equals 9.72 Gg and is the same as reported in last year's submission for the year 2009.

7.8.2 Other Emissions (5II)

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

Flooded Land

Emissions of CH_4 from reservoirs were estimated applying a comparative method as for CO_2 emissions using either reservoir classification or a reservoir specific emission factor (Óskarsson and Guðmundsson, 2008). In cases where information was available the emissions were calculated from inundated carbon. Emissions of N_2O are considered as not occurring. The Tier 1 method of the AFOLU Guidelines includes no default emission factors for N_2O. Zero emissions were measured in a recent Icelandic study on which the emission estimate is based (Óskarsson and Guðmundsson, 2008).

Estimated CH_4 emission from reservoirs is 0.40 Gg CH_4 and the same as in last year's submission.

7.8.3 Emission Factors

Reservoir specific emission factors are available for one reservoir classified as High SOC, three reservoirs classified as Medium SOC and six classified as Low SOC. For those reservoirs, where specific emission factors or data to estimate them 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 7.10).

Table 7.10. Emission factors applied to estimate emissions from flooded land based on (Óskarsson and Guðmundsson 2001; Óskarsson and Guðmundsson 2008; Óskarsson and Gudmundsson in prep).

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
Reservoir specific	0.392	0	0.0157	0
Reservoir specific	0.2472	0	0.0099	0
Average	0.162	0	0.0065	0
Medium SOC				
Reservoir specific	4.67	0	0.187	0.004
Reservoir specific	0.902	0	0.036	0.0008
Reservoir specific	0.770	0	0.031	0.0007
Average	2.114	0	0.085	0.0018
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 also bubble emission for the latter.

7.8.4 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 a conversion stage, although most of the land has been flooded for more than ten years.

7.8.5 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 a 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. The uncertainty of the emission factors applied is estimated as 50%, and of area as 20%.

7.8.6 *Planned Improvements regarding Wetland*

Improvements regarding information on reservoir area and type of land flooded are planned. Effort will be made to map existing reservoirs but many of them are not included in the present inventory. Introduction of reservoir specific emission factors for more reservoirs is to 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. Effort in connection with HiRes mapping under the CORINE program is planned and expected to improve maps of all wetland categories.

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

7.8.7 *Recalculations*

No recalculations were made for the category Wetland.

7.9 Settlement

The area of Settlement reported is the area estimate of IGLUD. A new map layer was used for the Settlement area (see chapter 0 p.136). The reported area is 51.85 kha compared to last year’s submission 71.04 kha.

7.9.1 *Carbon Stock Changes (5E)*

The AFOLU Guidelines are more extensive with respect to reporting emissions from settlements and land converted to settlement than the previous GPG for LULUCF, where the 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 and is further described above in chapter 7.5.5 (pages 171-172). The emissions reported are based on carbon stock estimates of the living biomass of the trees on the deforested land (T3 approach) and in country estimates of C-stock in dead organic matter and soil (T2 approach). The area reported in the inventory year as “Forest land converted to Settlement” is 0.07 kha and the attached estimated emission is 0.71 Gg CO_2.

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 extracted amount.

Part of the drained land is within the area classified as Settlement. Due to dis-aggregation 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.

7.9.2 Other Emissions (5)

As discussed above the area of drained wetlands, which is inside Settlement area, 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 7.12). No other sources of CH_4 or N_2O have been recognized.

7.9.3 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.

7.9.4 Planned Improvements regarding Settlement

The present estimate of Settlement area is based on IS50 v3.2 maps. Updated of IS50 maps are expected to reflect future changes in area of Settlement. Revision of changes in Settlement area using available supplementary data as total basal area of buildings as proxy is planned.

Geographic identification of the drained land under Settlement, and an independent estimate of emissions from that area, is planned in coming years.

7.10 Other Land (5F)

No emission/removal are 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 known 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 areas with vegetation cover < 20% or covered with mosses.

7.10.1 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.

7.11 Other (5)

One emission/removal category is reported under other i.e. Grassland Non-CO_2 emission Harvested Wood Products are not reported.

7.11.1 Harvested Wood Products

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

7.11.2 Wetland converted to Grassland Non CO_2 Emissions

Non-CO_2 emissions from Grassland are reported here. The present structure of Reporter software (version 3.6.2) 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. The emission estimate for this category has changed from last submission mostly due to changes in reported area. The estimated emissions in this year’s submission are 0.25 Gg N_2O or 77.9 Gg CO_2-equivalents compared to last year’s estimate, 0.25 Gg N_2O or 77.93 Gg CO_2-equivalents.

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”.

Emission Factors

Emissions of N_2O from drained organic soil under Grassland are calculated according to a Tier 2 using a new CS emission factor EF=0.44 [kg N_2O-N ha^{-1} yr^{-1}] (Gudmundsson 2009). The emission factor is based on direct measurements of N_2O emissions from drained grassland soils. The drained grassland soils in Iceland have not been ploughed seeded or fertilized and are not agricultural or cultivated soils.

7.12 Biomass Burning (5V)

Accounting for biomass burning in all land use categories is addressed commonly in this section. The only emissions reported are 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 has not been estimated for other categories due to lack of information.

Burning the biomass on grazing land near the farm was common practice in sheep farming in the past. 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.

7.12.1 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.

7.13 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 on-going and recent research activity on emissions/removal and stocks in several ecosystems will be used in emissions calculations.

8 WASTE

8.1 Overview

This sector includes emissions from solid waste disposal on land (6A), wastewater treatment (6B), waste incineration (6C), and biological treatment of solid waste (6D).

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

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

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

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

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

The special treatment of hazardous waste did not start until the 1990s, i.e. hazardous waste was landfilled or burned like non-hazardous waste. Special treatment started with the reusing of waste oil as energy source. In 1996 the Hazardous waste committee (*Spilliefnanefnd*) was founded and started a collection scheme for hazardous waste. The collection scheme included fees on hazardous substances that were refunded if the substances were delivered to hazardous waste collection points. Hazardous substances collected include oil products, organic solvents, halogenated compounds, isocyanates, oil-based paints, printer ink, batteries, car batteries, preservatives, refrigerants, and more. After collection, these substances were destroyed, recycled or exported for further treatment. The Hazardous waste committee was succeeded by the Icelandic recycling fund in late 2002. In 2011, 599 tonnes of hazardous waste were landfilled, 714 tonnes were incinerated, 6,267 tonnes were recycled, and 42 tonnes of acid were neutralized.

Clinical waste has been incinerated in incinerators either at hospitals or at waste incineration plants. 275 tonnes of clinical waste were incinerated in incineration plants in 2011.

The trend has been toward managed SWDS as municipalities have increasingly cooperated with each other on running waste collection schemes and operating joint landfill sites. This has resulted in larger SWDS and enabled the shutdown of a number of small sites. In 2011, more than 80% of all landfilled waste was disposed of in managed SWDS. Recycling of waste has increased due to efforts made by the government, local municipalities, recovery companies, and others. Composting started in the mid-1990s and has increased since then. Over recent years, composting has become a publically known option in waste treatment and a number of composting facilities have been commissioned.

In 2011, about 35% of all waste generated was landfilled, 57% recycled or recovered, 5% incinerated, and 3% composted.

Wastewater treatment in Iceland consists mainly in basic treatment with subsequent discharge into the sea. 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 63% of the population lives in the capital area and most of the larger industries are located within the area, mostly by the coast. In recent years, more advanced wastewater treatments have been commissioned in some smaller municipalities. Their share of total wastewater treatment, however, does not exceed 2%.

Aggregated greenhouse gas emissions from the waste sector amounted to 198 Gg CO_2 equivalents in 2011, which is tantamount to a 37% increase since 1990. Between 2010 and 2011, however, emissions from the waste sector have decreased by 5.7% due to a decrease of SWD emissions. Around 89% of all emissions from the waste sector (2011) are caused by solid waste disposal, 6% by wastewater treatment, 4% by waste incineration without energy recovery and 1% by composting. The development of greenhouse gas emissions from the waste sector is shown in Figure 8.1.

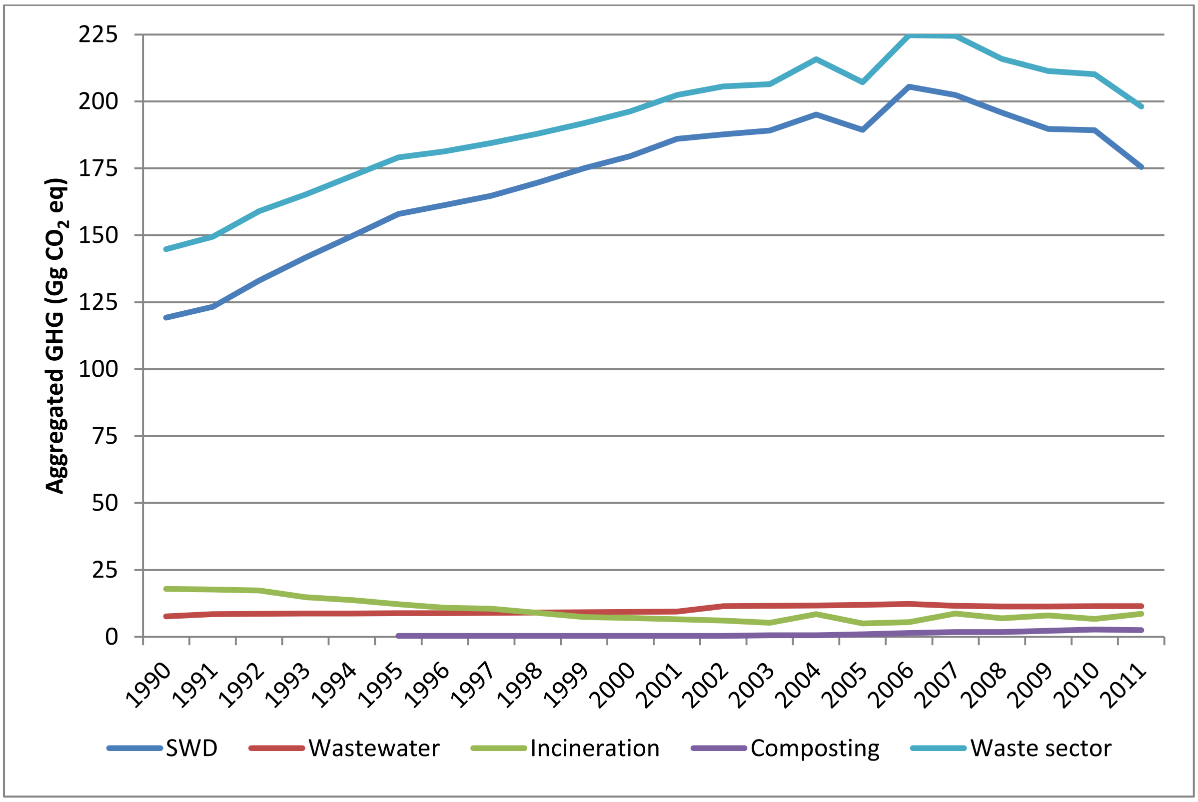

Figure 8.1. Greenhouse gas emissions from the waste sector in Iceland. CO_2, CH_4 and N_2O emissions were aggregated by calculating CO_2 equivalents for CH_4 and N_2O (factors 21 and 310, respectively). The top line is the sum of the four lines below.

8.1.1 Methodology

The calculation of greenhouse gas emissions from waste is based on the methodologies suggested by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 GL) and the Good Practice Guidance (GPG). Methodology for each greenhouse gas source category within the waste sector is described separately below.

8.1.2 Key source analysis

The key source analysis performed for the 2013 submission revealed that in terms of total level and/or trend uncertainty the key sources in the waste sector are as follows:

- Managed waste disposal on land – CH_4 (6A)
- This is a key source in level (2011) and trend
- Unmanaged waste disposal on land – CH_4 (6A)
- This is a key source in level (1990) and trend

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 greenhouse gas emission sources in the waste sector.

Table 8.1. Waste sector – completeness (E: estimated, NE: not estimated, IE: included elsewhere).

	Direct GHG			Indirect GHG		
Waste Categories	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Solid waste disposal on land (6A)						
- Managed (6A1)	NE	E	NE	NE	NE	NE
- Unmanaged (6A2)	NE	E	NE	NE	NE	NE
Wastewater treatment (6B)						
- Industrial (6B1)	NE	E	IE[2]	NE	NE	NE
- Domestic and commercial (6B2)	NE	E	E	NE	NE	NE
Waste incineration (6C)	E	E	E	E[1]	E[1]	E[1]
Other – Composting (6D)	NE	E	E	NE	NE	NE

1: Data also submitted under CLRTAP; 2: included in 6B2

8.1.4 *Source Specific QA/QC Procedures*

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

8.2 Solid waste disposal on land (6A)

8.2.1 *Methodology*

The methodology for calculating methane from solid waste disposal on land is according to the Tier 2 method of the 2006 GL and uses the 2006 IPCC First Order Decay method (FOD) for calculations. The method assumes that the degradable organic carbon (DOC) in waste decays slowly throughout the years or decades following its deposition thus producing methane and carbon dioxide emissions. The model was expanded to include additional waste categories. Therefore the Technical Support Unit of the IPCC NGGIP was contacted and provided the author with the password to unprotect the spread sheet.

8.2.2 *Activity data*

Waste generation

The Environment agency of Iceland (EA) has compiled data on total amounts of waste generated since 1995. This data is published by Statistics Iceland (Statistics Iceland, 2012). The data for the time period from 1995 to 2004 relies on assumptions and estimation and is less reliable than the data generated since 2005. In recent years the data has been based on questionnaires sent to the waste industry, which returns them with weighted waste amounts landfilled, incinerated, composted, or recycled. There can be a time lag between reassessment of waste generation data and its publication and, therefore, inconsistencies between older published data and newer data used in the GHG inventory. Three examples for these inconsistencies are the amount of timber burned in bonfires on New Year's Eve, the amount of landfilled manure, and waste from metal production. Until last year the amount of material burned annually in bonfires had been estimated to amount to up to 6 Gg. Beginning with last year the amount was calculated: first the material (mainly unpainted timber) that went into one of the country´s largest bonfires was weight and its mass correlated with the height and diameter of the timber pile. Then height and diameter for most of the country´s bonfires were used to calculate their weight. As a result the amount of timber burned in bonfires was estimated at less than 2 Gg in 2012. The result was projected back in time using expert judgement. Until last year the annual amount of manure landfilled manure was estimated at 10,000 tonnes. Closer inquiries revealed that the amounts actually landfilled were much smaller. The remaining amounts were so negligible that the waste category manure was suspended and allocated to the category sludge. Waste from metal production was not included because the amounts recorded by the EA are inconsistent between years. Estimation of waste from metal production started in 2002 and was assumed to be between 10 and 11 Gg annually until 2007. Since 2008 data collection is more comprehensive and based on reports by the metal industry. Since then amounts are estimated to be in excess of 100 Gg. Because of the data inconsistency and since the material is inert (with regard to CH_4 production) and recycled, it is left out of the data used to estimate waste generation before 1995. These are the main reasons that data reported here deviates from data reported to and published by Statistics Iceland.

Waste generation before 1995 was estimated using gross domestic product (GDP) as surrogate data. Linear regression analysis for the time period from 1995-2007 resulted in a coefficient of determination of 0.54. A polynomial regression of the 2nd order had more explanation power (R^2 = 0.8) and predicted waste for GDPs closer to the reference period, i.e. from 1990 to 1994, more realistically (Figure 8.2). Therefore the polynomial regression was chosen. More recent data was not used because the economic crisis that began in 2008 had an immediate impact on GDP whereas the impact on MSW generation was delayed therefore reducing the correlation between the two. Information on GDP dates back to 1945 and is reported relative to the 2005 GDP. It was therefore used to estimate waste generation since 1950. The formula the regression analysis provided is:

$$\textbf{Waste amount generated (t)} = -22.045 * \text{GDP index}^2 + 7367 * \text{GDP index}$$

The waste amount generated was calculated for total waste and not separately for municipal and industrial waste as was done in Iceland´s 2011 submission to the UNFCCC. The reason behind this is that the existing data on waste amounts does not support this distinction. Waste amounts are reported to the EA as either mixed or separated waste. Though the questionnaires send to the waste industry contain the two categories mixed household and mixed production waste, the differentiation between the two on site is often neglected. Therefore they can be assumed to have similar content. The fact that all other household and production waste is reported in separated categories makes the use of the umbrella category industrial waste obsolete (more on this in chapter 8.2.2).

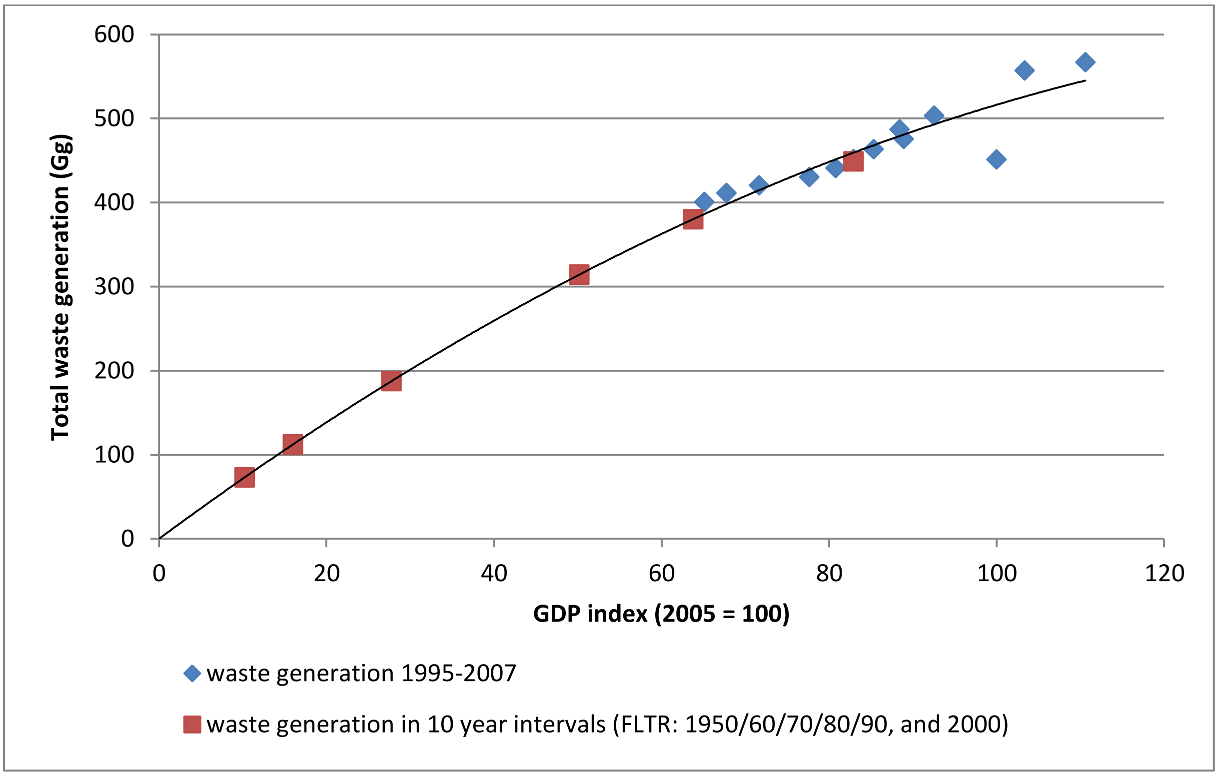

Figure 8.2. Waste generation from 1950-2011. Blue rhombuses denote waste generation between 1995 and 2007 and were used to calculate waste amounts before 1995, which are shown as red squares in 10 year intervals along the trend line.

Waste allocation

The data since 1995 described above, allocates fractions of waste generated to SWDS, incineration, recycling and composting. Recycling and composting started in 1995. For the time before 1995 the generated waste has to be allocated to either SWDS or incineration/open burning of waste. In a second step the waste landfilled has to be allocated to SWDS types and the waste incinerated to incineration forms. To this end population was used as surrogate data. It was determined that all waste in the capital area, i.e. Reykjavík plus surrounding municipalities, was landfilled since at least 1950 (expert judgement), whereas only 50% of the waste generated in the rest of the country was landfilled. The remaining 50% were burned in open pits. Calculated annual waste generation was multiplied with the respective population fractions. It is not improbable that more than half of the waste generated in the countryside was burned openly. Nevertheless, in order to not underestimate the emissions from SWDS this assumption was used until 1972. That year the SWDS in Akureyri opened and all waste generated in the town and, since 1990 in the neighbouring countryside, was landfilled there. In response to this the fraction of the population burning its waste was reduced accordingly, i.e. the 50% of waste that the population of Akureyri burned before the opening of the new landfill were allocated to SWDS. The same was done in response to the opening of another big SWDS in Selfoss in south Iceland in 1981. The waste management system fractions from 1950-2011 are shown in Figure 8.3.

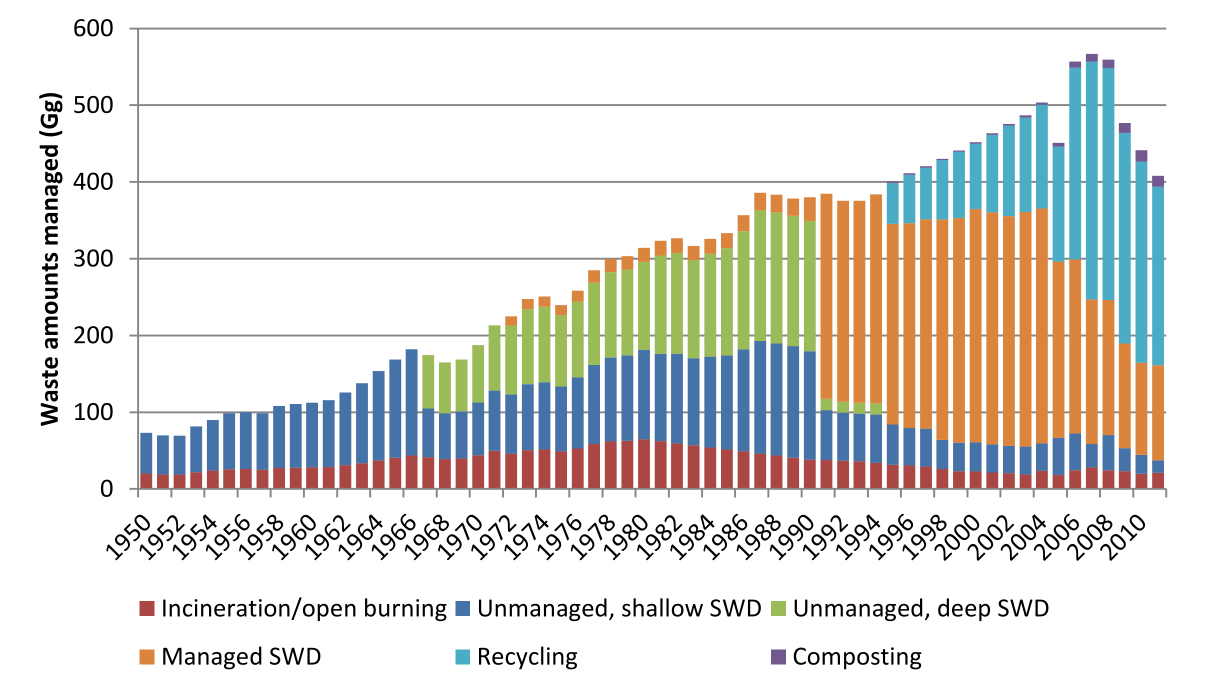

Figure 8.3. Waste amount and allocation to incineration/open burning, solid waste disposal, recycling and composting.

In accordance with the 2006 GL the amount of waste landfilled was allocated to one of three solid waste disposal site types:

- Managed – anaerobic (from here on referred to as just "managed")
- Unmanaged – deep (>5 m waste, from here on sometimes referred to as just "deep")
- Unmanaged – shallow (<5 m waste, from here on sometimes referred to as just "shallow")

From 1950 to 1966 all waste landfilled went to shallow sites. The fraction of total waste landfilled that went to shallow sites was reduced by the following events.

- In 1967 the SWDS Gufunes classified as deep SWDS was commissioned to serve Reykjavík.
- In 1972 the aforementioned SWDS in Akureyri was commissioned. Based on two landfill gas formation studies conducted there (Kamsma and Meyles, 2003; Júlíusson, 2011) it was classified as managed SWDS.
- In 1981 the aforementioned SWDS site in Selfoss was commissioned and was classified as deep SWDS.
- In 1991 Gufunes was closed down and in its place the SWDS Álfsnes was opened, now serving the capital and all surrounding municipalities. Álfsnes is the biggest SWDS in Iceland today and was classified as managed SWDS (thus reducing both shallow and deep SWDS fractions).
- In 1995 a new SWDS in south Iceland was opened. It received the waste that before had gone to the SWDS Selfoss plus waste of surrounding municipalities. Based on 2006 GL criteria it was classified as managed SWDS (thus reducing both shallow and deep SWDS fractions)

- In 1996 the SWDS Þernunes in eastern Iceland was opened. Based on 2006 GL criteria it was classified as managed SWDS.
- In 1998 the SWDS Fíflholt in western Iceland was opened. It was classified as managed SWDS based on 2006 GL criteria and landfill gas measurements (Kamsma and Meyles, 2003; Júlíusson, 2011)

Until 2004 the fractions of waste landfilled allocated to the different SWDS types are based on surrogate data (population). From 2005 onwards actual waste amounts going to the five sites classified as managed as well as going to the remaining shallow sites have been recorded by the EA. The change in data origin explains the rise in fraction of waste landfilled going to shallow sites in 2005 (Figure 8.4), i.e. shallow landfill sites receive a disproportionate amount of waste compared to the share of population they are serving.

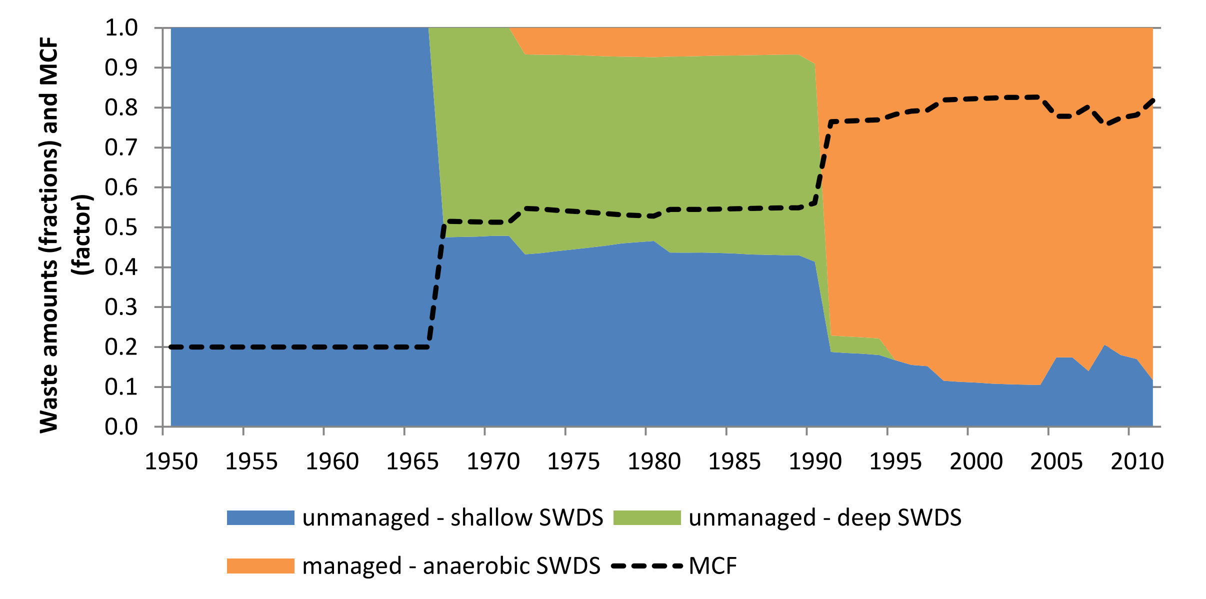

Figure 8.4. Fractions of total waste disposed of in unmanaged and managed SWDS and corresponding methane correction factor (see also: chapter 8.2.4)

Waste composition

Since 2005 the EA has gathered information about annual composition of waste landfilled, burned, composted, and recycled. This data consists of separated and mixed waste categories. The separated waste categories could be allocated to one of the following waste categories:

- Food waste
- Food industry waste
- Paper/cardboard
- Textiles
- Wood
- Garden and park waste
- Nappies (disposable diapers)
- Construction and demolition waste
- Sludge

- Inert waste

The last category comprises plastics, metal, glass, and hazardous waste. The pooling of these waste categories is done in the context of methane emissions from SWDS only. For purposes other than greenhouse gas emission estimation the EA keeps these categories separated. The mixed waste categories were allocated to the categories above with the help of a study conducted by Sorpa ltd., the waste management company servicing the capital area and operating the SWDS Álfsnes. Sorpa ltd. takes random samples from the waste landfilled in Álfsnes each year, classifies and weighs them. This data was used to attribute the mixed waste categories to the ten waste categories listed above. This was done for both mixed household and mixed production waste. As mentioned above there is no real distinction between the two. A third mixed category, mixed waste from collection points, does not contain food waste. Therefore the studies´ fractions without their food waste fractions were used to attribute this category to the waste categories from the list. Thus, all waste landfilled could be attributed to one of the ten waste categories listed above with changing fractions from 2005 to 2010. The average fractions from 2005-2011 were used as starting point to estimate waste composition of the years and decades before.

Although the data gathered by Sorpa ltd. dates back to 1999, the data from 1999-2004 could not be used to represent mixed waste categories. That is because the mixed waste categories in the data gathered by the EA have undergone changes during the same time period: many categories that have been recorded separately during the last five years had been included in the mixed waste category before 2005, thus multiplying the amount recorded as mixed waste. Also, for the time period from 1995-2004 the EA data does not permit exact allocation of waste categories to waste management systems.

Therefore the average waste composition from 1990-2004 is assumed to be the same as the average waste composition from 2005-2010. For the time before 1990 the waste composition fractions were adjusted based on expert judgement and a trend deductible from the Sorpa ltd. study data, namely that the amount of food waste is increasing back in time. The adjustments that were made are shown in Table 8.2.

Table 8.2. Manipulations of waste category fractions for the time period 1950-1990.

Waste category	Adjustment	Rationale
nappies/ disposable diapers	linear reduction by 100% between 1990 and 1980	Disposable diapers were introduced to Iceland around 1980 and were not widely used until the 1990s
paper/cardboard	linear reduction by 50% between 1990 and 1950	The fraction of paper in waste was assumed to be much smaller decades ago. Also, paper was rather burned than landfilled (expert judgement)
inert waste	linear reduction by 25% between 1990 and 1980 and linear reduction by 25% between 1980 and 1950	Plastic and glass comprise around 50% of inert waste. Glass was reused during the beginning of the period. Plastic was much rarer during the beginning of the period. The amount of plastic in circulation increased in the 1980s (data from Norway), therefore the steeper decrease during that decade.
food waste	increase of fraction by amount that other categories were reduced by	Expert judgement and trend in data from study by Sorpa ltd.

These adjustments led to the waste category fractions presented for a choice of years in Table 8.3. The increase in the food waste fraction between 2010 and 2011 can be explained by a more thorough sorting process before weighing in the study by Sorpa ltd. as well as an actual increase of the fraction due to a relative decrease of other fractions due to increased recycling.

Table 8.3. Waste category fractions for selected years since 1950.

	food	food industry	paper	textiles	wood	garden	diapers	demolition	sludge	inert
1950	48.2%	7.0%	9.4%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	18.7%
1960	42.8%	7.0%	11.7%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	21.7%
1970	37.3%	7.0%	14.1%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	24.8%
1980	31.9%	7.0%	16.4%	2.5%	3.3%	3.4%	0.0%	5.7%	1.8%	27.9%
1990	16.2%	7.0%	18.8%	2.5%	3.3%	3.4%	4.1%	5.7%	1.8%	37.1%
2005	15.2%	5.5%	20.9%	1.7%	4.7%	0.7%	3.6%	7.9%	0.5%	39.3%
2006	10.7%	5.2%	19.2%	1.9%	2.0%	5.5%	2.2%	9.1%	2.2%	42.0%
2007	13.0%	6.4%	18.8%	2.7%	5.9%	5.6%	3.4%	9.1%	2.2%	32.9%
2008	14.7%	8.3%	20.7%	3.3%	3.1%	4.0%	3.8%	2.1%	2.3%	37.7%
2009	19.0%	10.8%	11.2%	4.5%	3.1%	3.0%	5.8%	2.2%	2.2%	38.3%
2010	18.0%	8.6%	18.8%	1.9%	1.3%	1.7%	6.3%	1.3%	1.5%	40.5%
2011	31.0%	6.7%	19.4%	2.3%	1.9%	2.0%	6.5%	4.2%	1.6%	24.2%

8.2.3 Emission factors

Methane emissions from solid waste disposal sites are calculated with equation 3.1 of the 2006 GL:

Equation 3.1

$$CH_4 \text{ emissions} = \left(\Sigma_x CH_4 \text{ generated}_{x,T} - R_t \right) * \left(1 - OX_t \right)$$

Where:

CH_4 Emissions = CH_4 emitted in year T, Gg

T = inventory year

x = waste category or type/material

R_T = recovered CH_4 in year T, Gg

OX_T = oxidation factor in year T, (fraction)

The IPCC default of zero was used for OX_T. The amount of methane recovered will be discussed in chapter 8.2.4. In order to calculate methane generated, the FOD method uses the emission factors and parameters shown in Table 8.4.

Table 8.4. Emission factors and parameters used to calculate methane generated.

Emission factors/parameters	values
Degradable organic carbon in the year of deposition (DOC)	Table 8.5
Fraction of DOC that can decompose (DOC_f)	0.5
Methane correction factor for aerobic decomposition (MCF)	Table 8.6
Fraction of methane in generated landfill gas (F)	0.5
Molecular weight ratio CH_4/C	16/12 (=1.33)
Methane generation rate (k)	Table 8.5
Half-life time of waste in years (y)	Table 8.5
Delay time in months	6

DOC, k, and y (which is a function of k) are defined for individual waste categories. The respective values for most of the ten categories are 2006 GL defaults, except where indicated otherwise (Table 8.5).

Table 8.5. Degradable organic carbon (fraction), methane generation rate and half-life time (years) of ten different waste categories.

cate-gory	food	food industry[1]	paper	Tex-tiles	wood	garden	diapers	demolition	sludge	inert
DOC	0.15	0.1	0.4	0.24	0.43	0.2	0.24	0.04	0.05	0
k	0.185	0.1	0.06	0.06	0.03	0.1	0.1	0.03	0.185	NA
y	4	7	12	12	23	7	7	23	4	NA

1 country specific value aggregated for waste from fish and meat processing

The DOC of waste going to SWDS each year was weighted by multiplying individual waste category fractions (cf. Table 8.3) with the corresponding DOC values. The multiplication of annual values for mass of waste deposited with DOC, DOC_f, and the methane correction factor results in the mass of decomposable DOC deposited annually ($DDOC_m$).

The default methane correction factors for SWDS types account for the fact that unmanaged and semi-aerobic SWDS produce less methane from a given amount of waste than managed, anaerobic SWDS. The default values suggested by the 2006 GL for the three SWDS types used are shown in Table 8.6. The default for managed, anaerobic sites however, was lowered from 1 to 0.9 by expert judgement. The rationale behind this reduction was that - although the five SWDS contained in the category managed, anaerobic classify for it by the definition used by the 2006 GL - two of them (Þernunes and Kirkjuferjuhjáleiga) have reduced CH_4 production. This was found out by the two landfill gas studies already mentioned (Kamsma and Meyles, 2003; Júlíusson, 2011). The same studies reported no methane production for several of the SWDS contained in the category unmanaged, shallow. Therefore its MCF was reduced from 0.4 to 0.2. Multiplication of MCF with respective SWDS type fractions results in a fluctuating MCF for solid waste disposal (cf. Figure 8.4).

Table 8.6. IPCC methane correction factors and MCFs used in NIR 2012.

SWDS type	managed, anaerobic	unmanaged, deep	unmanaged, shallow
MCF (IPCC default)	1	0.8	0.4
MCF used	0.9	0.8	0.2

The FOD method is then used in order to establish both the mass of decomposable DOC accumulated and decomposed at the end of each year. To this end the k values of waste categories are used. A delay time of six months takes into account that decomposition is aerobic at first and production of methane does not start immediately after the waste deposition. Equations 3.4 and 3.5 from the 2006 GL to calculate DDOC accumulated and decomposed are shown below:

Equation 3.4

DDOC accumulated in SWDS at the end of year T

$$DDOCma_T = DDOC\ md_T + (DDOCmaT\text{-}1 * e^{-k})$$

Equation 3.5

DDOC decomposed at the end of year T

$$DDOCm\ decomp_T = DDOCma_{T\text{-}1} * (1-e^{-k})$$

Where:

T = inventory year

$DDOCma_T$ = DDOCm accumulated in the SWDS at the end of year T, Gg

$DDOCma_{T-1}$ = DDOCm accumulated in the SWDS at the end of year (T-1), Gg

$DDOCmd_T$ = DDOCm deposited into the SWDS in year T, Gg

$DDOCm\ decomp_T$ = DDOCm decomposed in the SWDS in year T, Gg

k = reaction constant, $k = \ln(2)/t_{1/2}$ (y^{-1})

$t_{1/2}$ = half-life time (y)

Finally, generated CH_4 is calculated by multiplying decomposed DDOC with the volume fraction of CH_4 in landfill gas (= 0.5) and the molecular weight ratio of methane and carbon (16/12=1.33)

8.2.4 Emissions

Methane recovery

The only SWDS recovering landfill gas is Álfsnes which serves the capital area. The existing data regarding recovered methane amounts was scrutinised between submissions and inconsistencies detected between the two main data sources, i.e. annual reports of the operator Sorpa ltd. and personal communication with Sorpa ltd. Therefore Sorpa ltd. was asked to reassess the data all the way back to the beginning of methane recovery in 1996. The reassessed data (Einarsson, personal communication) consisted of amounts in Nm^3 which were converted to kg by assuming standard conditions (0.717 kg at 0 °C and 101.325 kPa) and 95% purity. From 1996 until 2001 recovered methane was combusted only. The main use between 2002 and 2006 was electricity production. The bulk of methane recovered since 2007 is sold as fuel for vehicles, e.g. cars and urban buses. The more recent data is more accurate than older data since it is based on sold amounts whereas older data is estimated. Both methane recovery series from the 2012 and 2013 are shown in Figure 8.5. Recovery increased steadily between its beginning in 1996 and 2005. In 2006 the burner was damaged which led to a drop in the amount of methane recovered. Since then amounts have oscillated but show a strong increasing trend since 2010. In 2012 (data not shown) the recovered amounts surpassed the 2005 level.

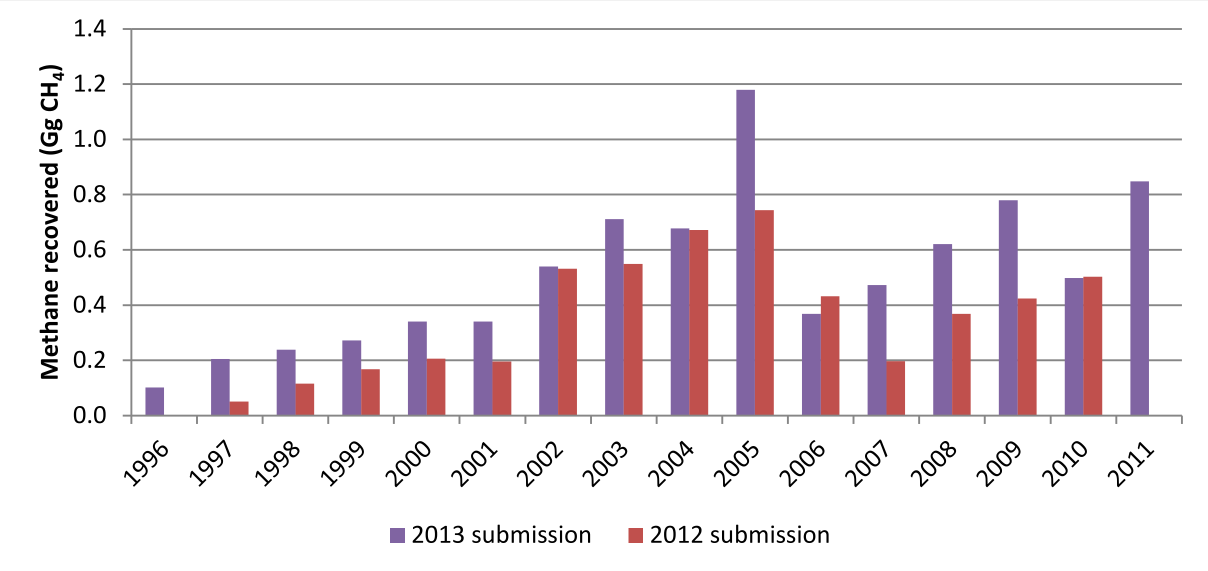

Figure 8.5. Methane recovery at solid waste disposal site Álfsnes (Gg CH_4). The violet column colour is identical to the colour used for methane recovery in Figure 8.6.

Methane emissions

In 1990 methane emissions from SWDS amounted to 5.7 Gg CH_4 and increased to 9.8 Gg in 2006. Since 2006 they decreased again and were estimated at 8.4 Gg in 2011. This is equals an increase of 47% between 1990 and 2010.

The main reason behind the increase until 2006 is a rather stable, high amount of waste disposed of in SWDS in connection with an increase of the methane correction factor caused by the close down of unmanaged SWDS in favour of managed SWDS. The shift in emissions from unmanaged to managed SWDS can be seen in Figure 8.6. In 1990 the fraction of CH_4 emissions from managed SWDS amounted to only 11% of all SWDS emissions, whereas the fraction of emissions from unmanaged SWDS accounted for 89%. This trend has been reversed since then and in 2010 84% of SWDS emissions originated from managed SWDS. The main event underlying this development is the close down of the unmanaged SWDS Gufunes accompanied by the simultaneous opening of the managed SWDS Álfsnes, which services more than half the population of Iceland and receives corresponding waste amounts.

The reason for the decrease since 2006 can be found in the changes in waste management: since 2003 the amount of waste landfilled is decreasing rapidly and an increasing amount of waste is recycled. Because of the relatively high fraction of rapidly decreasing waste the relatively new trend away from landfilling can already be seen in emissions.

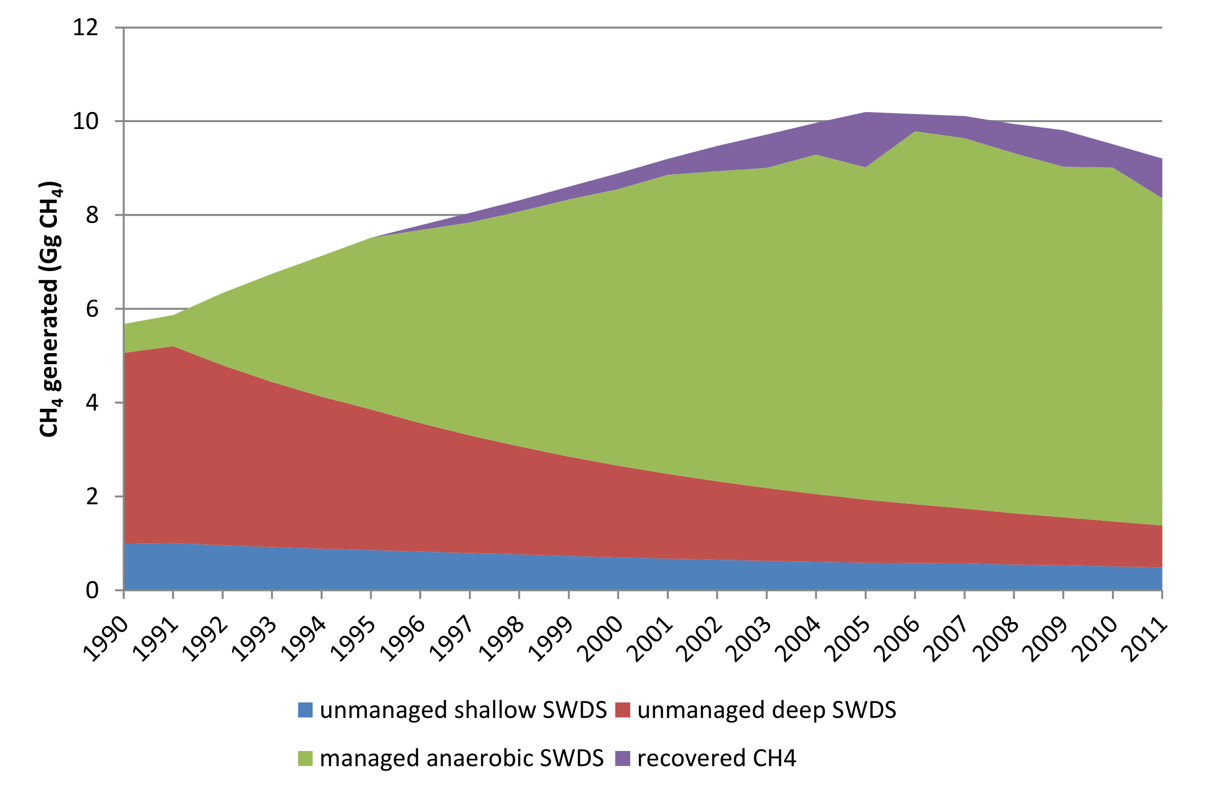

Figure 8.6. Methane emissions from SWDS, separated into SWDS types. The amount of methane recovered at the managed SWDS Álfsnes is shown as purple area (reducing the size of the green area for emissions from managed SWDS)

8.2.5 Changes to previous submissions and recalculations

There have been some changes and recalculations between the 2012 and 2013 submissions.

A) Waste generation

As mentioned above was the waste category manure abandoned after it was found out that the estimated amounts were grossly overestimated. This reduced waste amounts for the years 2005-2007 and influenced the outcome of the regression analysis used to estimate waste generation for the years before 1995. Since the waste amount were lowered for the end of the period used to estimate waste amounts between 1950 and 1994 the regression curve flattened thus increasing waste amounts before between 1 and 4% (Table 8.7).

Table 8.7. Difference in generated waste amounts between 2012 and 2013 submissions.

Decade	1950s	1960s	1970s	1980s	1990s	2000s
Mean increase of generated waste amount between submissions: (2012-2011)/2011	4.1%	3.6%	2.6%	1.5%	0.5%	-3.1%

B) Waste composition

One waste category (manure) was abandoned. Another waste category was added. In the 2012 submission waste from fish and meat processing were included in food waste. Since data on the amounts of waste from the fish and meat processing industry existed, these amounts were allocated to a new category: food industry waste. Based on a study by the engineering company Mannvit ltd. (Ívarsson et al., 2011) this waste was attributed with both lower DOC and k values than food waste.

C) Methane gas recovery

The changes between the reported amounts of methane gas recovered have been covered above (cf. chapter 8.2.4).

D) Summary

As a whole these changes caused a 4% decrease integrated over the whole period from 1990 to 2010 of estimated methane emissions between submissions. In 1990 the decrease was 3% and in 2010 it was 0.7%. The decrease was highest for 2005 (-8%) due to the pronounced difference in estimated methane recovery between submissions.

8.2.6 Uncertainties

Uncertainty analysis for CH_4 emissions from solid waste disposal was carried out in two steps. In the first step the uncertainty of total methane generation potential was calculated independent of the year during which emissions take place. In the second step k-values are manipulated in a sensitivity analysis to determine uncertainty regarding emission distribution over the years.

Total methane generation potential can be calculated by combining equations 3.2 and 3.3 in the 2006 GL (page 3.9) as product of

- mass of waste deposited (W)
- DOC
- DOC_F
- MCF
- Fraction F of methane in generated landfill gas,
- and the molecular weight ratio CH_4/C

The total waste amount and its composition constitute the activity data in these calculations. The uncertainty range for countries where waste is weighed at SWDS is in the range of +-10% according to table 3.5 in the 2006 GL (page 3.27). Since this practice has been implemented only in recent years and since data for the years before relies on assumptions and models, the higher value for countries collecting data on waste generation on a regular basis was chosen (+-30%). Waste composition is based on periodic sampling. Therefore the guideline value of +-30% uncertainty was chosen. These two values resulted in a combined AD uncertainty of 42%.

EF uncertainty consisted of the combined uncertainties of DOC, DOC_f, MCF and F. DOC, DOC_f and F were attributed with 2006 GL default uncertainties of 20, 20, and 5%, respectively. Different MCF uncertainties were attributed to each of the three SWDS types managed, unmanaged – deep, and unmanaged – shallow. The default MCF of 1 for managed SWDS is attributed with an uncertainty of -10%. Since Iceland lowered the default MCF to 0.9 an uncertainty of +-10% was assumed. The MCF for unmanaged – deep SWDS was attributed with the default uncertainty of +-20%. The uncertainty of the MCF for unmanaged – shallow SWDS, which had been lowered from 0.4 to 0.2 was estimated to be 100% in order to include the default value in the uncertainty range. This led to different combined methane generation potential EF uncertainties for the three pathways of 30% for managed, 35% for deep, and 112% for shallow, unmanaged SWDS.

In order to assign uncertainty of emission distributions over years, k-values were manipulated in a sensitivity analysis. The first order of decay model distributes methane emissions from SWDS by applying k-values and related half times to all waste categories. These k-values were varied within the error ranges given in the 2006 GL (Table 3.3, page 3.17). To that end the model was run first with default k-values, then with the lowest values of the range for each waste category (=slowest decay) and finally with the ranges´ highest values (= fastest decay). Resulting were three distinct emission progressions over time for each of the three SWDS management types. Generally, lower k-values mean less emissions (than default k-value emissions) during the early lifetime of SWDS followed by more emissions after a certain point in time (assuming similar waste amounts deposited annually). This general development can be seen for unmanaged SWD but not yet for managed SWDS since the waste amounts deposited there have been increasing until recently. Percentile uncertainties were quantified by dividing the highest absolute difference between the default k emissions and low/high emissions with the default emissions. Thus mean uncertainties of 19% and 13% resulted for managed and unmanaged SWDS, respectively. These uncertainties were combined with above mentioned EF uncertainties of the total methane generation potential. This increased total EF uncertainties slightly to 36% for managed SWDS and 38% and 104% for deep and shallow unmanaged SWDS, respectively. The latter two were combined by weighting them with 2011 emissions leading to a total EF uncertainties of unmanaged SWDS of 57%.

AD und EF uncertainties combined were 56% for managed SWDS and 71% for unmanaged SWDS.

8.2.7 Planned improvements

Currently there are no improvements planned regarding greenhouse gas emissions from wastewater treatment.

8.3 Emissions from Wastewater Handling (6B)

8.3.1 Overview

In the 1990s almost all wastewater was discharged directly into rivers or the sea. A small percentage was collected in septic systems. The share of septic systems has increased slightly and has been fluctuating around 10% since 2002. Septic systems in Iceland are used in remote places. These include both summer houses and building sites in the highlands such as the Kárahnjúkar hydropower plant. Since the turn of the century the share of direct discharge of wastewater has been reduced mainly in favour of collection in closed underground sewers with basic treatment. Basic or primary treatment includes e.g. removal of suspended solids by settlement and subsequent pumping of wastewater up to 4 km away from the coastline (capital area). Since 2002 some smaller municipalities have taken up secondary treatment of wastewater. This involves aerobic treatment, secondary settlement and removal of sludge. In eastern Iceland one of these wastewater facilities is in the process of attempting to use sewage sludge as fertilizer. Therefore the removed sludge is filled into ditches in order to let it break down.

The foremost industry causing organic waste in wastewater is fish processing. Other major industries contributing organic waste are meat and dairy industries. Industrial wastewater is either discharged directly into the sea or by means of closed underground sewers and basic treatment.

Several Icelandic site factors reduce methane emissions from wastewater, such as:

- a cold climate with mild summers
- a steep terrain with fast running streams and rivers
- an open sea with strong currents surrounding the island, and
- scarcity of population

Icelanders have a high protein intake which affects nitrous oxide emissions from wastewater.

Total CH_4 and N_2O emissions from wastewater amounted to 11.5 Gg CO_2 equivalents in 2011. Compared to 1990 emissions of 7.6 Gg CO_2 equivalents this means an increase of 51%.

Methodology

The calculation of greenhouse gas emissions from wastewater treatment in Iceland is based on the methodologies suggested by the 2006 IPCC Guidelines and the Good Practice Guidance. Wastewater treatment is not a key source in Iceland and country-specific emissions factors are not available for key pathways. Therefore the Tier 1 method was used when estimating methane emissions from domestic and industrial wastewater. To estimate the N_2O emissions from wastewater handling the default method given by the 2006 IPCC Guidelines was used.

8.3.2 Methane emissions from wastewater

Domestic wastewater

Activity data

Activity data for emissions from domestic wastewater treatment and discharge consists of the annual amount of total organics in wastewater. Total organics in wastewater (TOW) are calculated using equation 6.3 of the 2006 GL. In the equation annual amount of TOW is a product of population, kg biochemical oxygen demand (BOD) per head and year and a correction factor for additional industrial BOD discharged into sewers. The correction factor was set to zero since all methane emissions originate from domestic sewage. The 2006 GL default for Canada, Europe, Russia, and Oceania of 60 g BOD per person and day was used. Between 1990 and 2011 annual TOW increased proportionally to population from 5.6 Gg to 7 Gg.

Emission factors

Emission factors are a product of maximum CH_4 producing capacity for domestic wastewater (B_o) and discharge pathway specific methane correction factors (MCF). The default B_o of 0.6 kg CH_4/kg BOD suggested by the 2006 GL was applied. Four wastewater discharge pathways exist in Iceland. They are shown in Table 8.8 along with respective shares of total wastewater discharge and MCFs.

Table 8.8. Wastewater discharge pathways fractions and population of Iceland.

	untreated systems		**treated systems**		**population**
discharge pathway	flowing sewer, closed	sea, river and lake discharge	centralized, aerobic treatment plant	septic system	
1990	0.02	0.94	0.00	0.04	255,708
1995	0.04	0.90	0.00	0.06	267,806
2000	0.33	0.61	0.00	0.06	282,849
2005	0.54	0.33	0.02	0.11	299,404
2010	0.57	0.33	0.02	0.08	318,452
2011	0.57	0.33	0.02	0.08	319,575
MCF	0	0	0	0.3	

MCFs are in line with the 2006 GL except for the category sea, river and lake discharge. The 2006 GL propose a MCF of 0.1 and give a range of 0 – 0.2. Based on expert judgement a MCF of zero was used. The rationale behind this assessment is the cold climate in Iceland on the one hand and its fast running streams and rivers on the other hand. In Iceland the annual mean temperature for inhabited areas is 4 °C and the maximum temperature rises only occasionally above 15 °C, which is a threshold temperature for activity of methanogens. The geology of Iceland results in a hydrological setup with fast running streams and rivers. In combination with a low population density and therefore low organic loadings, this means that streams and rivers do not turn anaerobic. Thus, the only discharge pathway with a MCF (and emission factor) above zero is septic systems.

Total CH_4 emissions from domestic wastewater were calculated with equation 6.1 from the 2006 GL.

Equation 6.1

$$CH_4 \text{ emissions} = (\Sigma (T_j * EF_j)) * (TOW - S) - R$$

Where:

CH_4 emissions = CH_4 emissions in 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

T_j = degree of utilisation of treatment/discharge pathway or system, j, 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

The amount of sludge removed from septic systems cannot be distinguished from sludge removed during secondary treatment and was therefore set to zero. Since there is no recovery of wastewater methane, R was set to zero.

Emissions

Since septic tanks are the only wastewater treatment in Iceland attributed with an emission factor above zero, their fraction of total wastewater discharge determines the amount of methane emissions. This can be seen in Figure 8.7. The slight increase of TOW caused a slight increase of methane emissions during years when the share of septic tanks stayed unchanged. The sudden increase of emissions between 2001 and 2002 is due to an increase of septic system fraction from 6 to 11%. CH_4 emissions were highest in 2006, when they reached 0.22 Gg. In recent years the share of septic systems has decreased to 8%, which caused a decrease of emissions to 0.17 Gg in 2011. This is tantamount to an increase of wastewater treatment emissions of 150% since 1990. The decrease of septic systems in Iceland after 2008 was caused by the completion of the Kárahnjúkar hydropower plant where the wastewater of the workforce had been collected in septic tanks.

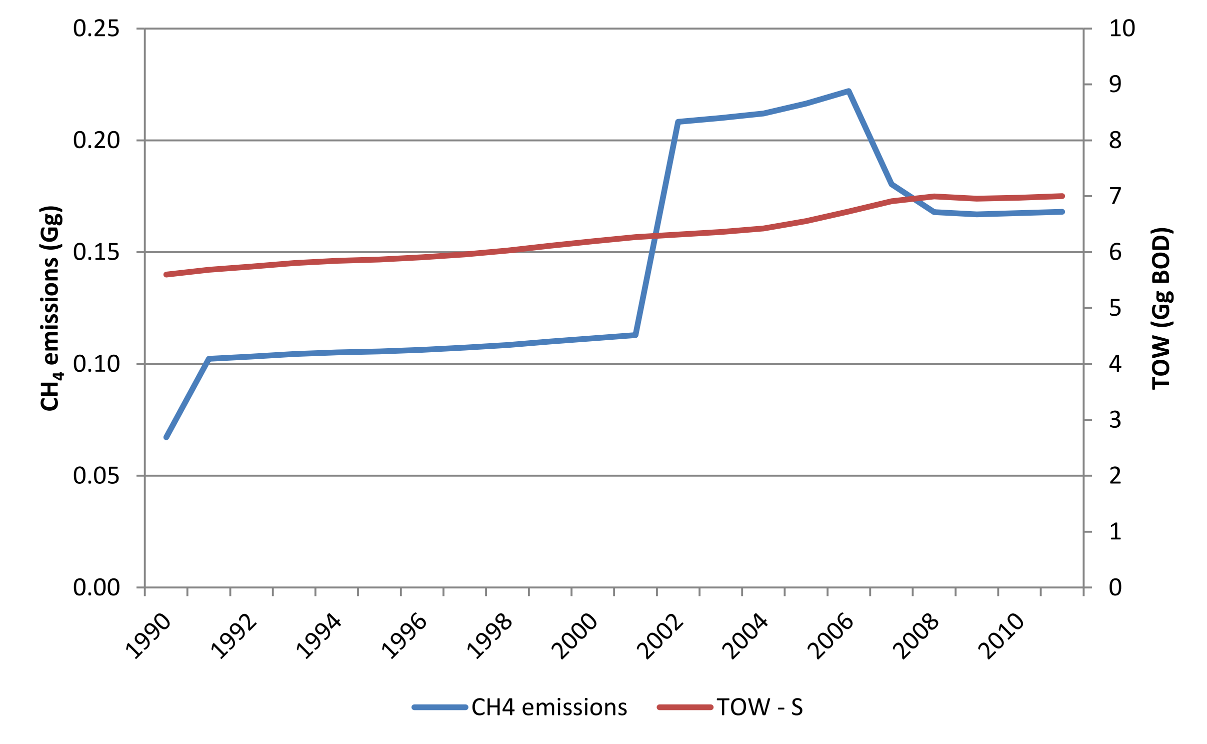

Figure 8.7. Methane emissions and total organics in wastewater (adjusted for removal of domestic septage (S)).

Changes to previous submissions and recalculations

In last year´s submission sludge removal was accounted for. This was changed in this year´s submission because it was not possible to distinguish between sludge amounts removed from discharge paths with emissions (septic tanks) and those without emissions (e.g. secondary treatment). This increased emission estimates by 0.7% and 0.2% for 1990 and 2010, respectively.

Industrial wastewater

Industrial wastewater in Iceland is untreated and either discharged directly into rivers or to the sea or by means of closed sewers. For industrial wastewater, the same MCFs as for domestic wastewater were used, i.e. zero. Therefore methane emissions from industrial wastewater are reported as not occurring.

8.3.3 Nitrous oxide emissions from wastewater

Activity data

The activity data needed to estimate N_2O emissions is the total amount of nitrogen in the wastewater effluent ($N_{EFFLUENT}$). $N_{EFFLUENT}$ was calculated using equation 6.8 from the 2006 GL:

Equation 6.8

$$N_{EFFLUENT} = (P * protein * F_{NPR} * F_{NON-COM} * F_{IND-COM}) - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = 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, kg N/yr

Fraction of nitrogen in protein, factor for non-consumed protein added to wastewater, and factor for industrial and commercial co-discharged protein are 2006 GL defaults and are shown in Table 8.9.

Table 8.9. Default parameters used to calculate amount of nitrogen in the wastewater effluent.

Parameter	Default value	Range	Remark
F_{NPR}	0.16		
$F_{NON-CON}$	1.4	1-1.5	The default value of 1.4 for countries with garbage disposal was selected.
$F_{IND-COM}$	1.25	1-1.5	Because of significant fish processing plants the upper limit of the range (1.5) was chosen.

Other parameters influencing the nitrogen amount of wastewater is country specific. The Icelandic Directorate of Health has conducted a number of dietary surveys both for adults (Steingrímsdóttir et al., 2002; Þorgeirsdóttir et al., 2012) and for children of different ages (Þórsdóttir and Gunnarsdóttir, 2006; Gunnarsdóttir et al., 2008). The studies showed a high protein intake of Icelanders of all age classes. Adults and adolescents consumed on average 90 g per day, 9 year olds 78 g and 5 year olds 50 g. These values as well as further values for infants were integrated over the whole population resulting in an average intake of 85 g per day and Icelander regardless of age.

The amount of sludge removed was multiplied with a literature value of 2% (N content of domestic septage; McFarland, 2000). This reduced total nitrogen content of wastewater by 3.8% (average 1990-2011).

Emission factor and emissions

The 2006 GL emission factor for N_2O emissions from domestic wastewater is 0.005 kg N_2O-N/kg N. In order to estimate N_2O emissions from wastewater effluent, the nitrogen in the effluent is multiplied with the EF and then converted from N_2O-N to N_2O by multiplying it with 44/28 (molecular weight of N_2O/molecular weight of N_2). The resulting emissions are shown in Figure 8.8. Emissions rose from 0.021 Gg in 1990 to 0.026 in 2011. This is tantamount to an increase of 28%. The main driver behind this development was a 25% increase of population during the same time.

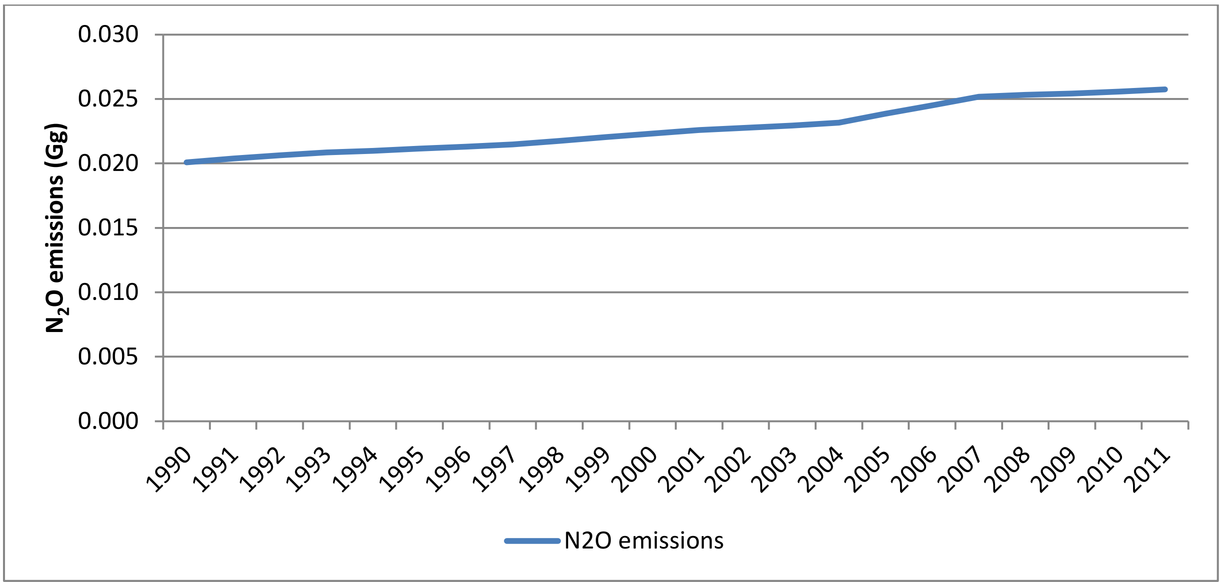

Figure 8.8. N_2O emissions from wastewater effluent between 1990 and 2010 in Gg.

8.3.4 Changes to previous submissions and recalculations

A comment made by the expert review team during its review of Iceland´s 2012 submission regarding the calculation of protein consumption led to its recalculation. This lowered the protein consumption from 87 to 85.3 g per day or by 1.9% leading to a proportionate decrease of N_2O emission estimates. Total differences in emission estimates between submissions were -2.3% and -2% for 1990 and 2010, respectively. The remaining difference is caused by reassessing the amount of sludge removed during wastewater treatment.

8.3.5 Uncertainties

AD uncertainty for N_2O emissions from wastewater were calculated by multiplying uncertainties of the five factors in the calculation of the amount of N in the wastewater effluent: population, protein content in diet, N content of protein and the two factors for additional N discharged by non-consumption and industry. Combined AD uncertainty was 46% and is not closer dissected here since it is dwarfed by an EF uncertainty of 1000% as given in table 6.11 of the 2006 GL (page 6.27), resulting in a combined uncertainty of 1001%. This can be seen in the quantitative uncertainty table in Annex II.

8.3.6 Planned improvements

Currently there are no improvements planned regarding greenhouse gas emissions from wastewater treatment.

8.4 Waste incineration (6C)

8.4.1 Overview

This chapter deals with incineration and open burning of waste. Open burning of waste includes now bygone combustion in nature and open dumps as well as combustion in incineration plants that do not control the combustion air to maintain adequate temperature and do not provide sufficient residence time for complete combustion. Proper incineration plants on the other hand are characterised by creating conditions for complete combustion. Therefore the burning of waste in historic incineration plants that did not ensure conditions for complete combustion was allocated to open burning of waste. The allocation has influence on CO_2, CH_4 and N_2O emission factors.

Open burning of waste is further divided into open burning of waste and bonfires. They differ from each other (from an emission point of view) in the composition of waste categories burned. Open burning of waste is used to incinerate a waste mix whereas bonfires contain only wood waste. Because wood does not contain any fossil carbon, CO_2 emissions from bonfires are not included in national totals.

Incineration of waste is subdivided into incineration with energy recovery (ER) and incineration without energy recovery. Emissions from incineration with ER are reported under the energy sector (1A1a and 1A4a) whereas emissions from incineration without ER are reported under the waste sector (6C).

The amount of waste burned in open pits decreased rapidly since the early 1990s, when more than 30 kilotonnes of waste were burned. Between 2005 and 2010 there was only one place burning waste in open pits: the island of Grímsey. It is assumed that around 45 tonnes of waste were burned there annually. The amount of material burned in bonfires has also decreased from around 4 kt in 1990 to less than 2 kt in 2010. Incineration of waste in incineration plants without energy recovery started in 2001 and incinerated waste amounts have been oscillating between 10 and 13 kt since 2004.

Total greenhouse gas emissions from waste incineration decreased from 17.9 Gg CO_2 eq. in 1990 to 8.5 Gg CO_2 eq. in 2001.

Methodology

The methodology for calculating carbon dioxide emissions from waste incineration is according to 2006 GL Tier 2a methodology. The methodologies for calculating methane and nitrous oxide emissions are in accordance with the 2006 GL Tier 1 methods.

Consistent with the 2006 Guidelines, only CO_2 emissions resulting from oxidation during incineration and open burning of carbon in waste of fossil origin (e.g. in plastics) are considered net emissions and therefore included in the national CO_2 emissions estimate. The CO_2 emissions from combustion of biomass materials contained in the waste (e.g. food and wood waste) are biogenic emissions and therefore not included in national total emission estimates. Other waste categories such as textiles, diapers, and rubber contain both fossil and biogenic carbon and are therefore included in CO_2 emission totals proportionally to their fossil carbon content.

CH_4, N_2O, NO_x, CO, NMVOC, and SO_2 emissions are estimated as well.

8.4.2 Activity data

Amount of waste incinerated

Methodology for activity data generation was inherited from the Icelandic submission to CLRTAP. The amount of waste burned openly is estimated using information on population in municipalities that were known to utilize open burning of waste and an assumed waste amount burned of 500 kg per head. The amount of waste burned in bonfires on New Year was calculated by weighing the wood of a sample bonfire and correlating the weight to the more readily measurable parameters pile height and diameter. These parameters were recorded for the majority of all bonfires and added up. The result was projected back in time using expert judgement. The amounts of waste incinerated are based on actual data from the incineration sites since 2004. The marginal amounts incinerated between 2001 and 2004 are based on expert judgement. The amounts of waste incinerated are shown in Figure 8.9.

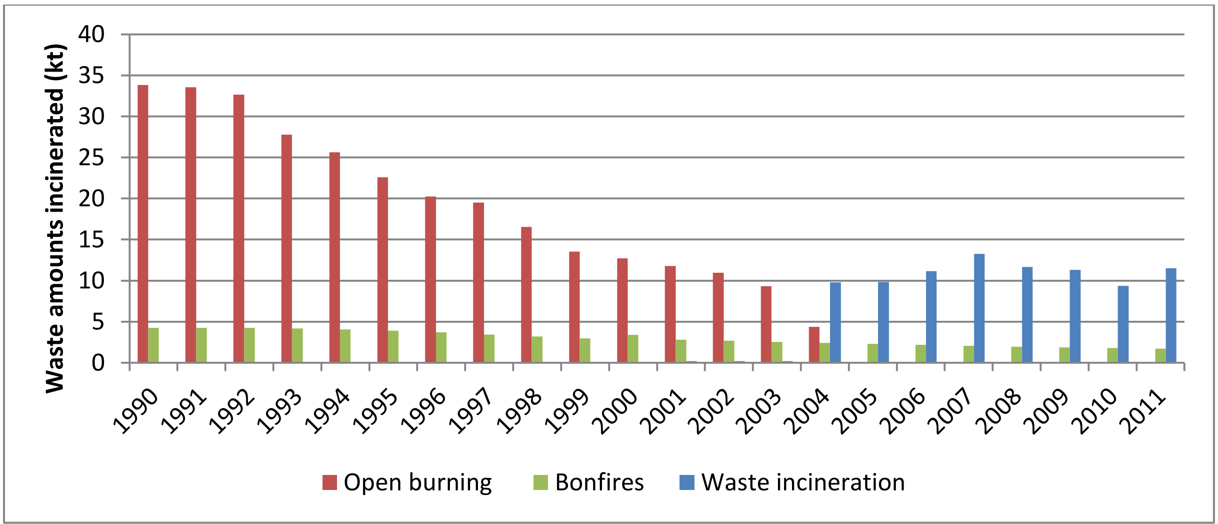

Figure 8.9. Amounts of waste incinerated without energy recovery, burned openly and amount of woodburned in bonfires.

Fig. 8.9 shows that waste was only burned openly (here this includes waste incinerators with low/varying combustion temperatures) and in bonfires during the 1990s. A small incineration plant operated in Tálknafjörður in northwest Iceland from 2001-2004. The incineration plant Kalka in southwest Iceland, which started operation in 2004, is the biggest one of its kind in Iceland. It produces energy and electricity for its own requirements and therefore rates as auto producer. Thus it is categorized as incineration plant without energy recovery.

Composition of waste incinerated

There exists data on the composition of waste incinerated since 2005. A fraction of this data is in the form of separate waste categories whereas another fraction is in the form of mixed waste categories. The mixed waste categories were divided into separate categories using the study by Sorpa ltd. for SWDS. The mixed share of waste incinerated is deemed to contain the same waste components as mixed waste landfilled, since incineration plants often took over the function of SWDS at their locations. By including the separate waste categories, however, the special function of some of the incineration plants – such as destruction of clinical and hazardous waste - are taken into account. Thus it was possible to allocate waste to one of the 11 categories shown in Figure 8.10 along with their weight fractions from 2005 to 2011. The category inert waste is defined differently here than it was defined for the SWDS chapter. In this context it excludes plastics, rubber and hazardous waste.

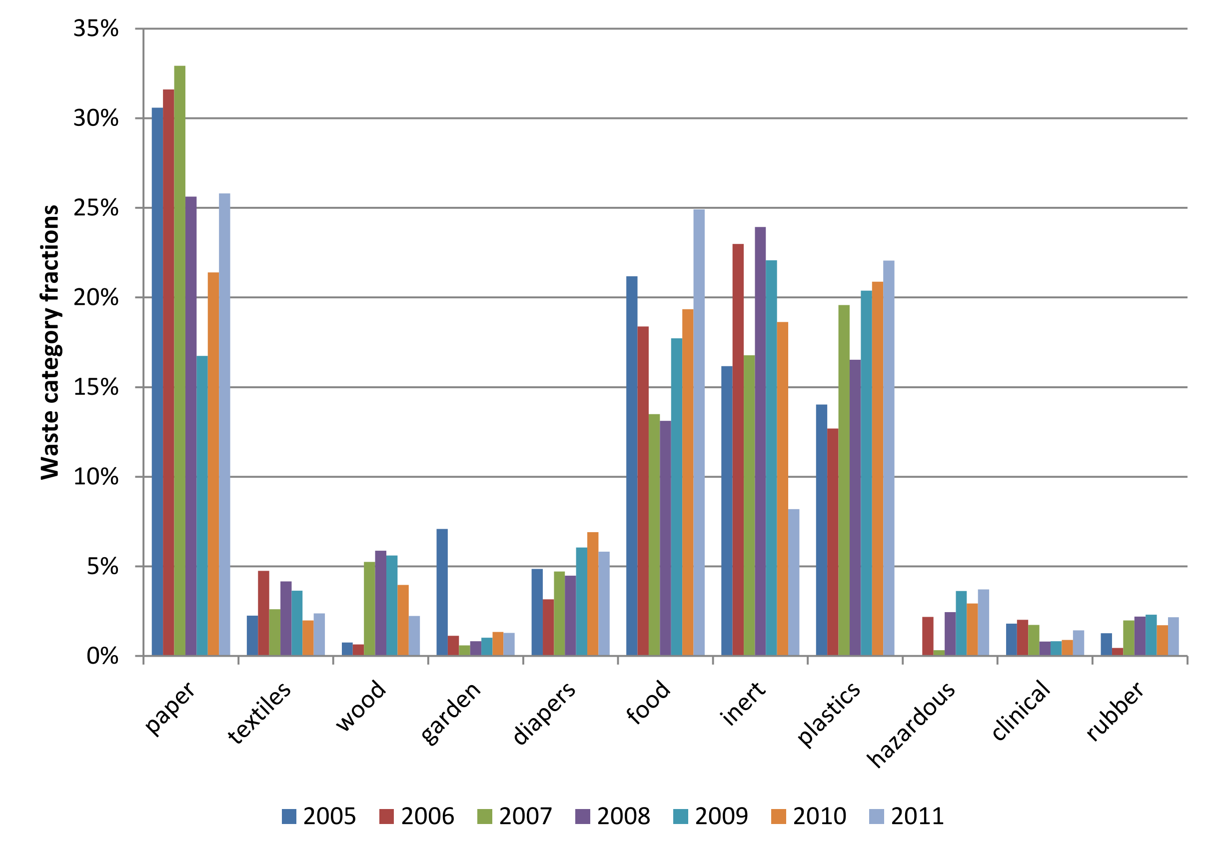

Figure 8.10. Waste categories for incineration along with weight fractions for 2005-2010 and the average weight fraction of whole period.

This data exists only for waste incineration and for the years from 2005 to 2011. For want of data from 1990-2004, weighted average fractions from 2005-2011 were applied to the period before 2005, i.e. to both incineration and open burning of waste (waste incineration plants often succeeded open burning of waste). Although the standard of living in Iceland has increased during the last two decades thus affecting waste composition, this method was deemed to yield better results than the Tier 1 method (with IPCC default waste composition).

8.4.3 Emission factors

CO_2 emission factors

CO_2 emissions were calculated using equation 5.3 from the 2006 GL (see below). As described for SWDS, there is no distinction between municipal solid and industrial waste. Therefore total waste incinerated was entered into the calculation instead of municipal solid waste.

Equation 5.3

$$CO_2 \text{ emissions} = MSW * \Sigma_j (WF_j * dm_j * CF_j * FCF_j * OF_j) * 44/12$$

Where:

CO_2 Emissions = CO_2 emissions in inventory year, Gg/yr

MSW = total amount of municipal solid waste as wet weight incinerated or open-burned, Gg/yr

WF_j = fraction of waste type/material of component j in the MSW (as wet weight incinerated or openburned)

dm_j = dry matter content in the component j of the MSW incinerated or open-burned, (fraction)

CF_j = fraction of carbon in the dry matter (i.e., carbon content) of component j

FCF_j = fraction of fossil carbon in the total carbon of component j

OF_j = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

with: $\Sigma_j WF_j = 1$

j = component of the MSW incinerated/open-burned such as paper/cardboard, textiles, food waste, wood, garden (yard) and park waste, disposable nappies, rubber and leather, plastics, metal, glass, other inert waste.

As oxidation factors 2006 GL defaults of 1 for waste incineration (= complete oxidisation) and 0.58 for open-burning were used. The equation first calculates the amount of fossil carbon incinerated. This is shown exemplary for the year 2011 in Table 8.10.

Table 8.10. Calculation of fossil carbon amount incinerated in 2011. The column "fossil carbon (wet weight basis), fraction" is the product of the three columns preceding it.

	waste category	waste category	dry matter	carbon content (dry weight basis)	fossil carbon (total carbon basis)	fossil carbon (wet weight basis)	fossil carbon
tonnes/fractions	weight	fraction	fraction	fraction	fraction	fraction	weight
paper	2,971	0.26	0.90	0.46	0.01	0.004	12
textiles	273	0.02	0.80	0.50	0.20	0.080	22
wood	257	0.02	0.85	0.50	0.00	0.000	0
garden	148	0.01	0.40	0.49	0.00	0.000	0
diapers	670	0.06	0.40	0.70	0.10	0.028	19
food	2,867	0.25	0.40	0.38	0.00	0.000	0
inert	944	0.08	0.90	0.03	1.00	0.027	25
plastics	2,539	0.22	1.00	0.75	1.00	0.750	1,904
hazardous	428	0.04	0.50	0.55	1.00	0.275	118
clinical	165	0.01	0.65	0.62[1]	0.63[1]	0.250	41
rubber	250	0.02	0.84	0.67	0.20	0.113	28
sum	11,512						2,170

1: both values generated to result in 2006 GL default fossil carbon content of 0.25

The input for individual years from 2005 to 2010 differs from Table 8.10 in the distribution of waste category fractions and total waste amount incinerated. For the time period from 1990-2004 the weighted average waste category fractions from 2005-2011 were combined with annual amounts incinerated. The same fractions were used for open burning of waste. In bonfires only timber (packaging, pallets, etc.), which does not contain fossil carbon, is burned. Therefore no CO_2 emissions from bonfires were reported.

CH_4, N_2O, NO_x, CO, and NMVOC emission factors

In contrast to CO_2 emission factors, which are applied to the fossil carbon content of waste incinerated, the emission factors for CH_4, N_2O, NO_x, CO, NMVOC, and SO_2 are applied to the total waste amount incinerated. Emission factors for CH_4 and N_2O are taken from the 2006 GL. They differ between incineration and open burning of waste. Emission factors for NO_x, CO, and NMVOC are taken from the EMEP/EEA air pollutant emission inventory guidebook (EEA, 2009), chapter 6.C.c: Municipal waste incineration. The EMEP guidebook defaults are applied to both open burning and incineration of waste. Defaults for these greenhouse gases are shown in Table 8.11.

Table 8.11. Emission factors (EF) for incineration and open burning of waste. All values are in g/tonne wet waste except where indicated otherwise.

Greenhouse gas	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Incineration EF	237	60	1800	700	20	400
Open burning EF	6500	150[1]	1800	700	20	400

1: g/tonne dry waste

8.4.4 Emissions

GHG emissions from incineration and open burning of waste are shown in Figure 8.11. CO_2 Emissions from open burning of waste decreased from 11.3 Gg in 1990 Gg to 8 Gg in 2011 thereby following the generally decreasing trend in incinerated waste amounts. CH_4 emissions from waste incineration decreased more rapidly or from 5.2 Gg CO_2 eq. in 1990 to 0.3 Gg in 2011. The reason more this more pronounced decrease is the switch from open burning of waste to waste incineration which goes along with reduced methane EF (cf. Table 8.11). N_2O emissions decreased from 1.4 Gg CO_2 eq. in 1990 to 0.3 Gg in 2011. This decrease is caused by both decreasing waste amounts and a lower EF for waste incineration as opposed to open burning of waste. Aggregated GHG emissions from waste incineration and open burning of waste decreased by 52% during this period.

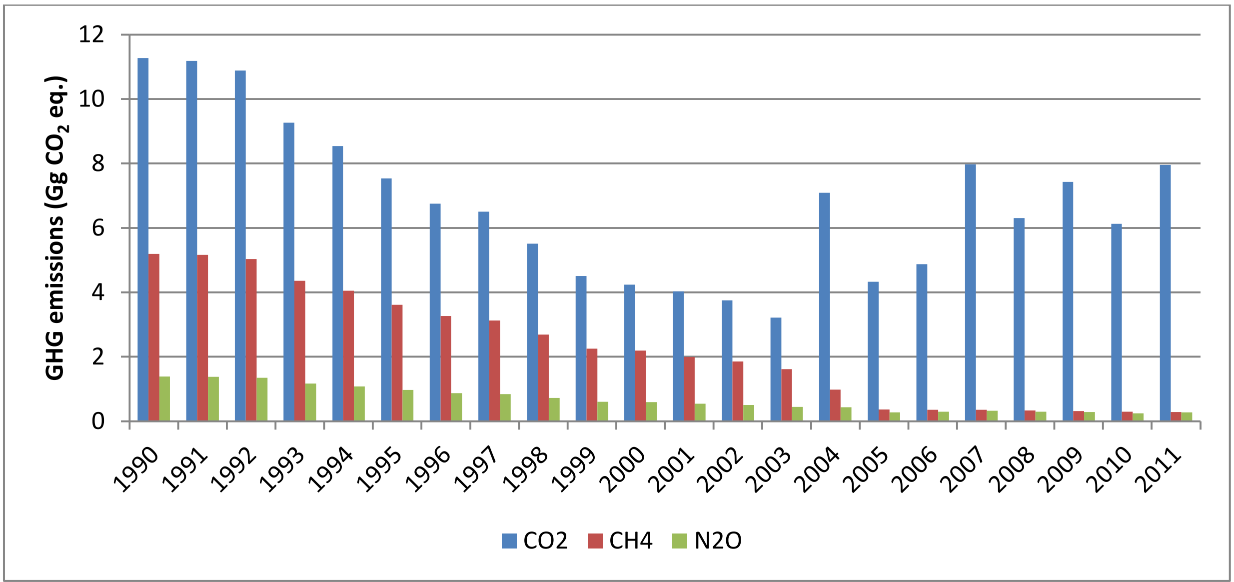

Figure 8.11. CO_2 emissions from incineration and open burning of waste in Gg.

8.4.5 Changes to previous submissions and recalculations

The major change between the 2012 and 2013 submissions is the reallocation of one incineration plant from waste incineration without energy recovery in the 2012 submission to waste incineration with ER (1A1a) in the 2013 submission. The incineration plant in Húsavík uses the energy produced during combustion to heat water which is then fed into the district heating. This reallocation decreases 2010 CO_2, CH_4, and N_2O emissions from waste incineration by one fourth between submissions (waste share incinerated in Húsavík of total waste incinerated without ER in 2012 submission). This reallocation has no impact on base year emissions since Húsavík did not start waste incineration until 2006.

Waste composition was reassessed leading to a slightly higher fraction of fossil carbon which in itself increased CO_2 emissions by 5.5% (average of all years in period).

The impact of the interaction of these changes on greenhouse gas emissions from open burning of waste and waste incineration without ER between 2011 and 2012 submissions is shown in Table 8.12.

Table 8.12. Changes in greenhouse gas emissions between 2011 and 2012 submissions. All emissions in Gg CO_2 equivalents.

GHG	year	2011 submission	2012 submission	change between submissions	main reason for change
CO_2	1990	10.7	11.3	5.5%	increase of waste fossil carbon content
	2010	8.3	6.1	-25.8%	allocation of one plant to waste incineration with ER
CH_4	1990	5.2	5.2	0.0%	no change
	2010	0.3	0.3	-5.3%	allocation of one plant to waste incineration with ER
N_2O	1990	1.4	1.2	-11.9%	decrease in dry matter content of waste open burned
	2010	0.3	0.2	-20.2%	allocation of one plant to waste incineration with ER
aggregated GHGs	1990	17.3	17.7	2.4%	increase of waste fossil carbon content
	2010	8.9	6.7	-24.9%	allocation of one plant to waste incineration with ER

8.4.6 Uncertainties

AD uncertainty of CO_2 emissions from incineration and open burning of waste was estimated by propagating uncertainty estimates of each step throughout the five step calculation process of determining the fossil carbon content of each of the waste categories incinerated. This process includes estimating and combining uncertainties of the total amount of waste incinerated, of waste category fractions, dry matter fractions, total carbon fractions, and fossil carbon fractions. The uncertainty of the total amount of waste incinerated was assumed to be ±20%. Waste categorization was also assumed to be known with ±20% accuracy. That means that the amount of each waste category incinerated was assumed to be known with a 28% uncertainty (combining total waste amount and waste composition uncertainties). Dry matter fractions of all waste categories were assumed to be known with 20% accuracy (expert judgement). Each waste category was then assigned total and fossil carbon fraction uncertainties by applying the ranges for the default values given in table 2.4 on page 2.14 of the 2006 GL. All five uncertainties were combined by multiplication (equation 6.4 of the GPG) for each waste category resulting in an estimate of the uncertainty of the each category´s fossil carbon fraction. These fractions were combined by addition using equation 6.3 on page 6.12 of the GPG. The equation demands uncertain quantities. The absolute fossil carbon fractions of waste incinerated from 2005-2011 acted as uncertain quantities in the equation in order to weight waste categories due to their relative importance for the CO_2 emission estimate. The total AD uncertainty was thus estimated to be 34%.

Emission factor uncertainties for open burning were calculated by applying the EF range given in table 5.2 on page 5.18 of the 2006 GL, resulting in an EF uncertainty of 18% for open burning. Uncertainty of the oxidation factor of 1 for incineration was estimated to be 5% (expert judgement). These differing EF uncertainties were integrated over the whole period from 1990-2011 by weighting them with the sum of all years´ CO_2 emissions resulting in an EF uncertainty of 14% and a total uncertainty of CO2 emissions from waste incineration of 37%.

Uncertainties of CH_4 and N_2O emissions were estimated by combining AD uncertainty of waste amount (=20%) with EF uncertainty (=100%) supplied by the 2006 GL (page 5.23). This resulted in combined uncertainties of 102% for both GHGs.

8.5 Biological treatment of solid waste: composting (6D)

8.5.1 Overview

Composting on a noteworthy scale has been practiced in Iceland since the mid-1990s. Data collection regarding the amount of waste composted started in 1995. Composted waste mainly includes waste from slaughterhouses, garden and park waste, timber, and manure. Garden and park waste has been collected from the Reykjavík capital area and composted using windrow composting, where grass, tree crush, and horse manure is mixed together. In some municipalities there is an active composting program where most organic waste is collected and composted. Increased emphasis is placed on composting as an option in waste treatment for the future as is evident by the recent commissioning of composting facilities in Sauðárkrókur and Eyjafjörður (2009) in northern Iceland as well as of smaller facilities elsewhere in Iceland. The amount of waste composted has been increasing from 2,000 tonnes in 2002 to roughly 15,000 tonnes in 2011 thus constituting roughly 3% of all waste treated.

Methodology

Estimation of CH_4 and N_2O emissions from composting are calculated using the Tier 1 method of the 2006 GL.

8.5.2 Activity data

There exists data about the amount of waste composted since 1995. The amount composted is estimated to be between 2000 and 3000 tonnes annually until 2004. Since 2005 this amount has increased by roughly 2000 tonnes per year and was around 15,000 tonnes in 2010 (Figure 8.12). There exists data on the composition of waste composted since 2007. In 2010 the main waste types composted were garden and park waste, slaughterhouse waste, food waste, and wood. The Tier 1 method, however, makes no use of waste composition data.

8.5.3 Emission factors

Both CH_4 and N_2O emissions from composting are calculated by multiplying the mass of organic waste composted with the respective emission factors. The 2006 GL default emission factors are (on a wet weight basis):

- 4 g CH_4/kg waste treated
- 0.3 g N_2O/kg waste treated

8.5.4 Emissions

CH_4 emissions from composting amounted to 0.06 Gg CH_4 or 1.3 Gg CO_2 equivalents in 2011. N_2O emissions amounted to 0.005 Gg N_2O or 1.4 Gg CO_2 equivalents in 2011. This is shown in Figure 8.12.

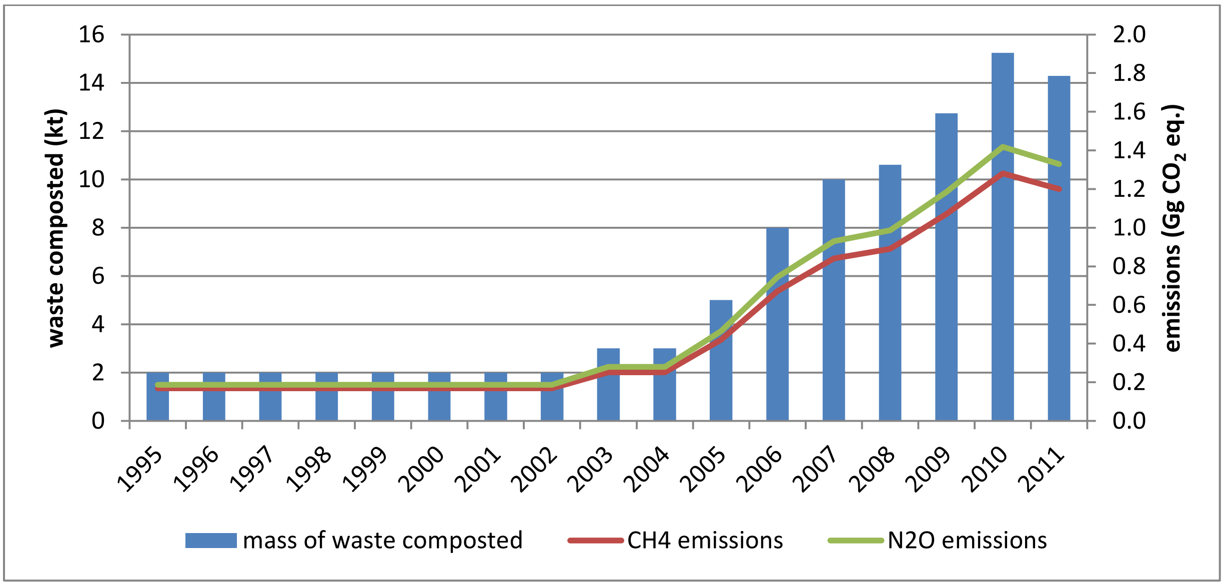

Figure 8.12. Mass of waste composted and resulting CH_4 and N_2O emissions (in Gg CO_2 eq).

8.5.5 Uncertainties

Uncertainty for emissions from composting was calculated using value ranges from the 2006 GL (table 4.1, page 4.6). CH_4 emission factors from composting range from 0.03-8 g/kg wet waste treated. Thus uncertainty was calculated to be (4-0.03)/0.03 = 13233%. The same calculation for N_2O resulted in an uncertainty of 400%. The EF uncertainty overshadowed the assumed AD uncertainty of 20% (expert judgement).

8.5.6 Planned improvements

Currently there are no improvements planned regarding greenhouse gas emissions from composting.

9 Recalculations

9.1 Overall Description of Recalculations

The Icelandic 2013 greenhouse gas emission inventory has been recalculated to some extent (Table 9.1). All recalculations made are calculated for the entire time series 1990-2010. Recalculations for some components and sources have been made to account for new knowledge and/or more accurate approximation of activity data and emission factors. Detected calculation errors have been removed. The figures reported in this submission are therefore consistent throughout the whole time series.

The biggest differences in emission estimates between submissions were recorded for the industry and LULUCF sectors. Methodology, activity data, and emission factors for HFC consumption in the refrigeration and air conditioning sector were revised. This led to an increase of emission estimates which was highest in 2010 (53 Gg Co_2 eq.). Carbon stock change factors for forest land were revised and changed between submissions. This led to decreased removal from Forest Land by up to 69 Gg CO_2 and thus increased net emissions from the LULUCF sector.

All recalculations and improvements taken together (disregarding LULUCF) led to slightly increased emission estimates for the base year or 0.2%. For 2010 the increase was more pronounced with 1.7%.

Table 9.1. Total recalculations in 2013 submission compared to 2012 submission (without LULUCF) in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase (Gg)	Increase (%)
1990	3,501	3,508	7	0.2%
1995	3,274	3,286	12	0.4%
2000	3,845	3,876	31	0.8%
2005	3,819	3,833	14	0.4%
2008	4,959	4,994	35	0.7%
2009	4,700	4,751	51	1.1%
2010	4,542	4,618	76	1.7%

9.2 Specific description of recalculations

9.2.1 Energy

Recalculations made in the energy sector between the 2012 and 2013 submissions were:

- CO_2, CH_4 and NMVOC emissions from distribution of oil products have been estimated for the first time.

- Composition of waste incinerated was re-examined. This led to slight (below 0.3 Gg) increases of aggregated emissions from waste incineration under 1A1A and 1A4A from 1993 to 2011.
- One waste incineration plant was reallocated from the Waste sector to the Energy sector which led to increases between 1.5 and 2.5 Gg CO_2 eq. under 1A1A for the period from 2006-2010.
- Activity data for kerosene in the residential sector was corrected for the year 2010.

Taken together these recalculations between submissions led to slight emission estimate increases over the complete time period. These increases amounted to 0.4 Gg CO_2 equivalents for 1990 and 2.9 Gg CO_2 equivalents for 2010 (Table 9.2).

Table 9.2. Recalculations of emission estimates for the Energy sector between the 2012 and 2013 submissions in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	1,778	1,779	0.4	0.0%
1995	1,916	1,916	0.6	0.0%
2000	2,041	2,042	0.7	0.0%
2005	2,075	2,076	0.5	0.0%
2008	2,072	2,075	2.8	0.1%
2009	2,018	2,021	3.2	0.2%
2010	1,866	1,869	2.9	0.2%

9.2.2 Industry

Recalculations made in the Industrial Processes sector between the 2012 and 2013 submissions were:

- Activity data for shell sand was corrected for the mineral wool industry for the years 2007 to 2010, based on new data from the single operating plant.
- Emissions of CO_2 in the ferroalloys industry is now calculated according to Tier 3 method, which is based on the mass balance approach. Plant and year specific C-contents of input and output materials are used.
- Emissions of CO_2 from consumption of electrodes in the aluminium industry are now calculated by using plant and year specific C-contents of the electrodes.
- The revision of methodology of emission estimates of consumption of HFC and SF_6 is described in more detail below.

The first three recalculations led to slight emission estimate increases over the complete time period. These increases amounted to 6 Gg CO_2 equivalents for 1990 and 27 Gg CO_2 equivalents for 2010. By adding recalculations regarding HFC emissions the difference of emission estimates between submissions increases to 80 Gg in 2010 (Table 9.3).

Table 9.3. Recalculations of emission estimates for the Industrial Processes sector between the 2012 and 2013 submissions in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	863.0	869.0	6.0	0.7%
1995	531.0	546.1	15.1	2.8%
2000	937.7	976.4	38.7	4.1%
2005	904.2	934.6	30.4	3.4%
2008	1974.5	2019.5	45.1	2.3%
2009	1797.9	1860.6	62.7	3.5%
2010	1809.6	1898.8	80.1	4.4%

Consumption of Halocarbons and SF_6

HFC emission estimates from consumption of HFCs have undergone major changes between the 2012 and 2013 submissions. The most important changes are listed below:

- The number of refrigeration and air conditioning sub-sources was increased from three in the 2012 submission (domestic and commercial refrigeration, MACs) to six in the 2013 submission (transport and industrial refrigeration as well as residential AC were added). These additions are based on more information about and a better understanding of the Icelandic refrigeration sector.
- Concomitant with the addition of new sources was an allocation diversification of HFC bulk import. In the 2012 submission all bulk import with the exception of 5% of the imported R-134A quantity was allocated to commercial refrigeration, the remainder was allocated to MACs. In the 2013 submission bulk import was allocated to all sub-sources with the exception of MACs.
- HFC stock of and emissions originating from refrigerated containers were recorded for the first time
- Initial emissions and end-of-life emissions were estimated for the first time in the 2013 submission.
- The lifetime emission factor for commercial refrigeration stayed unchanged. However, the lifetime EF of transport refrigeration, the sub-source now receiving the bulk of imported HFC quantities, was assessed as being considerably higher, i.e. 50% in 1993 and then linearly decreasing to 23.2% in 2010.

Total HFC emissions from refrigeration and air conditioning equipment for the year 2010 were estimated at 122 Gg CO_2 eq. in the 2013 emission which is a 54 Gg or 78% increase from the estimate in the 2012 submission (68 Gg CO_2 eq.). One third of this increase can be attributed to the correction of a calculation error in last year´s submission, which allocated the first lifetime emissions of imported HFC to the year following the import year instead of the import year itself. Around 50% of the increase is caused by increasing the lifetime emission factor for the bulk of the HFC quantity imported to Iceland. Other, more minor factors increasing HFC emission estimates are the addition of initial and end-of-life emissions, the detection of emissions from refrigerated containers, and the increased estimate regarding the amount of MACs in the Icelandic vehicle fleet, which increases the emissions from MACs by 44% (in combination with increasing charge sizes for trucks and coaches). Emissions from the domestic refrigeration sector increased almost seventy-fold. This enormous relative increase, which is an absolute increase of just 0.06 Gg CO_2 eq., is easily explained by the inclusion of end-of-life emissions, which – due to the very low lifetime EF of domestic refrigeration – constitute 93% of total domestic refrigeration emissions.

The differences between the 2012 and 2013 submissions' estimates are summarized in Table 9.4 and visualized in Figure 9.1.

Table 9.4. Recalculations of emission estimates for HFC consumption of refrigeration and air conditioning equipment between the 2012 and 2013 submissions in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	NO	NO	NA	NA
1995	0.3	8.5	8.2	2436%
2000	19.1	35.8	16.7	87%
2005	34.4	57.7	23.3	68%
2008	47.9	69.9	22.0	46%
2009	54.5	94.3	39.8	73%
2010	68.2	121.8	53.5	78%

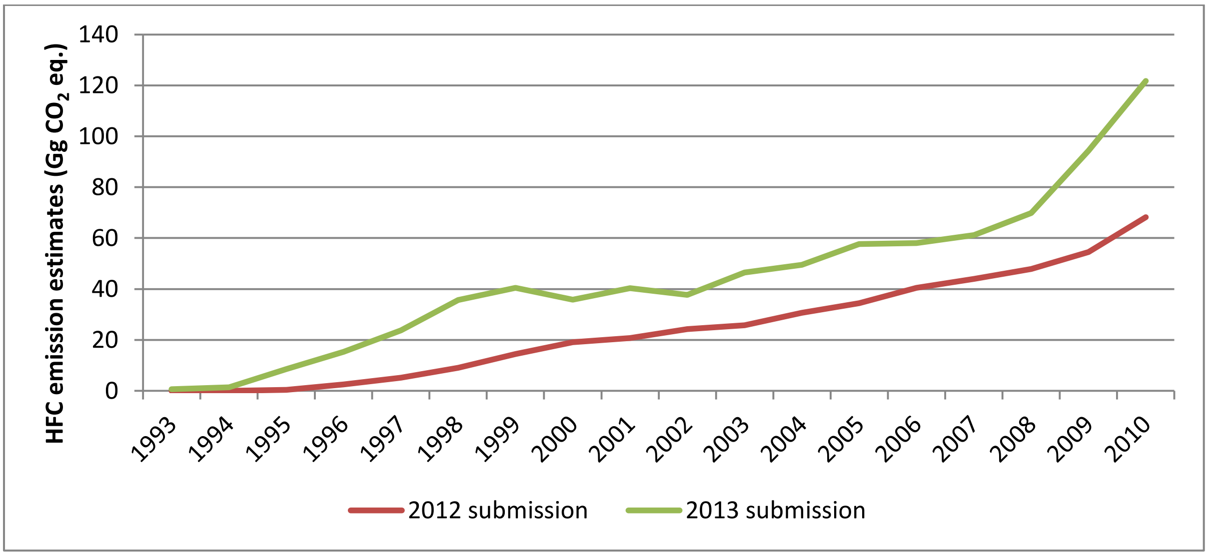

Figure 9.1. Recalculations of emission estimates for HFC consumption of refrigeration and air conditioning equipment between the 2012 and 2013 submissions in Gg CO_2-equivalents.

The activity data for SF_6 emissions from electrical equipment was reviewed and it was found that it only contained SF_6 amounts contained in the Icelandic electricity transmission system administered by Landsnet LLC. A number of energy intensive plants like aluminium smelters as well as an aluminium foil producer, however, have their own SF_6 employing high voltage gear. These amounts were included as activity data and information on reported leakage from these new sources were included in emission estimates.

Methodology was moved from Tier 1 to Tier 2 methodology with consequences for emission factors used. The Tier 1 methodology used in the 2012 submission used a high emission factor for installation emissions (6%) leading to high emissions in years when new equipment was set up, e.g. in 1999. After consultation with Landsnet LLC it was found that these installation emissions were overestimated.

The change in methodology removed previous emission peaks in 1999 and 2007 among other years and slightly lowered the estimate in 2010 (Table 9.5).

Table 9.5. Recalculations of emission estimates for SF_6 consumption of electrical equipment between the 2012 and 2013 submissions in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	1.1	1.1	0.0	2%
1995	1.5	1.3	-0.2	-11%
2000	3.1	1.4	-1.7	-55%
2005	4.2	2.6	-1.6	-38%
2008	6.3	3.2	-3.1	-50%
2009	5.9	3.2	-2.8	-47%
2010	4.9	4.9	-0.1	-1%

9.2.3 Solvent and other Product Use

No recalculations were made in this sector between the 2012 and 2013 submissions.

9.2.4 Agriculture

In last year´s submission an error occurred while transcribing data received from the AUI. The area development of cultivated organic soils was transcribed backwards: 1990 values were put in as 2010 values and vice versa. This lead to a reported area increase when in reality area was decreasing. During the review of Iceland´s 2012 submission the error was detected and corrected.

The revision increased estimates of direct emissions from soils for all years before 2000 and decreased estimates for all years afterwards. The differences for 1990 and 2010 were in each case 10.7 tonnes N_2O: 10.7 tonnes higher for 1990 and 10.7 tonnes lower for 2010. Emission estimates for all years in between behave linearly between these two points (Table 9.6).

Table 9.6. Recalculations of emission estimates for direct N_2O emissions from soils between the 2012 and 2013 submissions in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	145.5	148.9	3.3	2%
1995	133.4	135.0	1.7	1%
2000	143.6	143.6	0.0	0%
2005	126.3	124.6	-1.7	-1%
2008	158.5	155.8	-2.7	-2%
2009	141.2	138.2	-3.0	-2%
2010	134.7	131.4	-3.3	-2%

9.2.5 LULUCF

The emissions of several LULUCF categories were revised resulting in overall changes of CO_2 and N_2O emission estimates from the LULUCF sector. The results of these recalculations are summarized in Table 9.7 and Table 9.8. Total CO_2 emissions for 2010 increased from 646.56 Gg CO_2 in the 2012 submission to 708.61 Gg CO_2 reported in this year's submission. Reported N_2O emissions decreased slightly for the year 2010 between submissions: from 78.91 Gg CO_2 eq. reported in the 2012 submission to 78.86 Gg CO_2 eq. reported this year.

Table 9.7. Recalculations of CO_2 emission estimates from LULUCF

	2012 submission	2013 submission	Increase (Gg)	Increase (%)
1990	1117.8	1100.9	-16.9	-1.5%
1995	1055.0	1032.4	-22.5	-2.1%
2000	922.5	934.7	12.2	1.3%
2005	794.2	821.9	27.7	3.5%
2008	707.7	772.7	65.0	9.2%
2009	672.0	747.6	75.6	11.2%
2010	646.6	708.6	62.0	9.6%

Table 9.8. Recalculations of N_2O emission estimates from LULUCF (Gg CO_2 equivalents)

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	68.91	68.89	-0.02	-0.03%
1995	70.03	70.01	-0.02	-0.03%
2000	72.53	72.52	-0.01	-0.01%
2005	75.20	75.22	0.02	0.02%
2008	77.96	77.93	-0.02	-0.03%
2009	78.73	78.69	-0.04	-0.05%
2010	78.91	78.86	-0.05	-0.06%

Forest land

The emission/removal estimate for forest land has undergone major revision 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. Additionally time series for stock changes are reported for the first time for the cultivated forest and estimates for the natural birch forest are totally revised with new estimate methods for both for area and C-stock changes. As result of these recalculations the total reported removal for the year 2010 decreased from 271 Gg CO_2-equivalents in the 2012 submission to 214 Gg CO_2-equivalents in this year's submission or by 21% (Table 9.9).

Table 9.9. Recalculation results for CO_2 and N_2O emissions from forest land in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	-31.8	-43.9	-12.1	38%
1995	-52.3	-68.8	-16.5	32%
2000	-120.0	-106.2	13.8	-12%
2005	-184.5	-157.8	26.7	-14%
2008	-238.4	-175.9	62.5	-26%
2009	-258.5	-189.9	68.7	-27%
2010	-270.8	-214.0	56.8	-21%

Grassland

The area estimates of both natural birch shrubland subcategories were revised as was the carbon stock change estimate of these categories. The changes in area affected the area estimate of other subcategories and consequently their emission estimates. The overall removal of the Grassland category decreased from 170.55 Gg CO_2 reported for the year 2010 in 2012 submission to 164.9 Gg CO_2 reported in this year's submission (Table 9.10).

Table 9.10. Recalculation results for CO_2 emissions from grassland in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	-50.39	-55.06	-4.67	9%
1995	-69.20	-75.12	-5.92	9%
2000	-105.47	-106.93	-1.46	1%
2005	-141.69	-140.68	1.01	-1%
2008	-157.76	-155.06	2.70	-2%
2009	-165.37	-158.40	6.97	-4%
2010	-170.55	-164.92	5.63	-3%

The organic soils of Natural birch shrubland are estimated for the first time in this year's submission. Revised area estimates of Grassland subcategories also resulted in some changes in the areas of organic soils of several categories and consequently in minor changes of N_2O emission estimates. These changes are summarized in Table 9.11. N_2O emissions decreased by 0.27 Gg CO_2 eq for the year 2010 between the 2012 submission and this year's.

Table 9.11. Recalculations of Grassland non-CO_2 emissions in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	68.7	68.6	-0.2	-0.2%
1995	69.6	69.5	-0.2	-0.2%
2000	71.8	71.7	-0.2	-0.2%
2005	74.3	74.2	-0.2	-0.2%
2008	77.0	76.8	-0.2	-0.3%
2009	77.7	77.5	-0.2	-0.3%
2010	77.9	77.7	-0.3	-0.3%

Settlements

The emission estimate for forest land converted to settlements has undergone changes between submissions. Annual area of forest land converted to settlements has been revised after detection of a methodological error. Until the 2012 submission only the concerned year´s converted area had been reported. In the 2013 submission the area converted to settlements of each preceding year was added to the recent year´s conversion. The carbon stock change estimate for living biomass has been revised and the carbon stock change factors for dead organic matter and soils have been estimated for the first time in this year´s submission. Taken together these changes increased emission estimates for the time period from 2004-2009 but lowered estimates for 2010 by 0.14 Gg CO_2 due to the reduction of the carbon stock change estimate for living biomass (Table 9.12).

Table 9.12. Recalculation results for CO_2 emissions from settlements in Gg CO_2-equivalents.

	2012 submission	2013 submission	Increase Gg	Increase %
1990	NE	NO	NO	NA
1995	NE	NO	NO	NA
2000	NE	NO	NO	NA
2005	0.07	0.18	0.11	159%
2008	NE	0.08	0.08	NA
2009	NE	0.08	0.08	NA
2010	0.22	0.08	-0.14	-65%

9.2.6 Waste

Solid Waste Disposal on Land

There have been some changes and recalculations between the 2012 and 2013 submissions.

E) Waste generation

The waste category manure abandoned after it was found out that the estimated amounts were grossly overestimated. This reduced waste amounts for the years 2005-2007 and influenced the outcome of the regression analysis used to estimate waste generation for the years before 1995. Since the waste amount were lowered for the end of the period used to estimate waste amounts between 1950 and 1994 the regression curve flattened thus increasing waste amounts before between 1 and 4% (Table 9.13).

Table 9.13. Recalculation results for CH_4 emissions from SWD in Gg CO_2-equivalents.

Decade	1950s	1960s	1970s	1980s	1990s	2000s
Mean increase of generated waste amount between submissions: (2012-2011)/2011	4.1%	3.6%	2.6%	1.5%	0.5%	-3.1%

F) Waste composition

One waste category (manure) was abandoned. Another waste category was added. In the 2012 submission waste from fish and meat processing were included in food waste. Since data on the amounts of waste from the fish and meat processing industry existed, these amounts were allocated to a new category: food industry waste. Based on a study by the engineering company Mannvit ltd. (unpublished results), this waste was attributed with both lower DOC and k values than food waste.

G) Methane gas recovery

The changes between the reported amounts of methane gas recovered have been covered above (cf. chapter 8.2.4).

H) Summary

As a whole these changes caused a 4% decrease integrated over the whole period from 1990 to 2010 of estimated methane emissions between submissions. In 1990 the decrease was 3% and in 2010 it was 0.7%. The decrease was highest for 2005 (-8%) due to the pronounced difference in estimated methane recovery between submissions (Table 9.14)

Table 9.14. Recalculation results for CH_4 emissions from solid waste disposal in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	122.8	119.3	-3.6	-3%
1995	163.5	157.9	-5.6	-3%
2000	188.6	179.6	-9.0	-5%
2005	204.9	189.4	-15.5	-8%
2008	203.7	195.7	-7.9	-4%
2009	199.1	189.6	-9.4	-5%
2010	190.6	189.3	-1.4	-1%

Wastewater

In last year´s submission sludge removal was accounted for. This was changed in this year´s submission because it was not possible to distinguish between sludge amounts removed from discharge paths with emissions (septic tanks) and those without emissions (e.g. secondary treatment). This increased CH_4 emission estimates by 0.7% and 0.2% for 1990 and 2010, respectively.

A comment made by the expert review team during its review of Iceland´s 2012 submission regarding the calculation of protein consumption led to its recalculation. This lowered the protein consumption from 87 to 85.3 g per day or by 1.9% leading to a proportionate decrease of N_2O emission estimates. Total differences in emission estimates between submissions were -2.3% and -2% for 1990 and 2010, respectively. The remaining difference is caused by reassessing the amount of sludge removed during wastewater treatment.

Total wastewater emission estimates of the 2012 and 2013 emissions are shown in Table 9.15.

Table 9.15. Recalculation results for CH_4 and N_2O emissions from wastewater in Gg CO_2-equivalents.

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	7.8	7.6	-0.1	-2%
1995	8.9	8.8	-0.1	-2%
2000	9.4	9.3	-0.1	-2%
2005	12.3	11.9	-0.3	-3%
2008	11.5	11.4	-0.1	-1%
2009	11.5	11.4	-0.1	-1%
2010	11.6	11.4	-0.2	-1%

Waste incineration

The major change between the 2012 and 2013 submissions is the reallocation of one incineration plant from waste incineration without energy recovery in the 2012 submission to waste incineration with ER (1A1a) in the 2013 submission. The incineration plant in Húsavík uses the energy produced during combustion to heat water which is then fed into the district heating. This reallocation decreases 2010 CO_2, CH_4, and N_2O emissions from waste incineration by one fourth between submissions (waste share incinerated in Húsavík of total waste incinerated without ER in 2012 submission). This reallocation has no impact on base year emissions since Húsavík did not start waste incineration until 2006.

Waste composition was reassessed leading to a slightly higher fraction of fossil carbon which in itself increased CO_2 emissions by 5.5% (average of all years in period).

The impact of the interaction of these changes on greenhouse gas emissions from open burning of waste and waste incineration without ER between 2011 and 2012 submissions is shown in Table 9.16.

Table 9.16. Recalculation results for CO_2, CH_4 and N_2O emissions from waste incineration in Gg CO_2-equivalents

Inventory year	2012 submission	2013 submission	Increase Gg	Increase %
1990	17.3	17.9	0.6	3%
1995	11.7	12.1	0.4	3%
2000	6.8	7.0	0.2	3%
2005	4.9	5.0	0.0	1%
2008	9.2	6.9	-2.3	-25%
2009	10.7	8.0	-2.7	-25%
2010	8.9	6.7	-2.2	-25%

9.3 Planned improvements

In the near future the following improvements for the inventory are planned:

- Preparation of a national energy balance. The NEA should prepare a national energy balance annually and submit to the EA. Work has already been initiated by the NEA, with the aim of producing the national energy balance within two years. The obligation of the NEA to provide national energy balance will be further elaborated in a regulation, to be set on basis of Act no 70/2012.
- Improvement of methodologies to estimate emissions from road transportation (use of COPERT).
- Move estimates of emissions from aviation to the Tier 2 methodology.
- Improvement of methodologies to estimate N_2O emissions from manure management.
- Developing a time series for the enhanced livestock population characterisation
- The division of land use into subcategories and improved time and spatial resolution of the land use information is an on-going task of the AUI.
- 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.
- Continued gathering of information on various C-pools in each land use category and application of this information to improve stock change estimates.
- Improving identification of former cropland categories and destination of abandoned cropland.
- Improvements of area estimate for different soil types under Cropland.
- Establishing reliable estimates of cropland biomass is also important and is planned in the summer 2013.
- Continued work on improving the area estimate of drained organic soils of Grassland.
- On-going national forest inventory (NFI) will further improve both estimates of Forest land area and Carbon stock changes.
- Quality assessment of C-stock changes of biomass in cultivated forest by calculation of statistical error values of the NFI.

- Similar efforts to the the NFI regarding Revegetation began in 2007. The Revegetation inventory is expected to provide improved data on carbon stock changes and the area of revegetated land in the next two years.
- Further improvement of the time series already presented.
- The provision of missing Annexes.
- Preparation of a comprehensive improvement plan.

The following improvements are under consideration:

- Develop CS emission factors for fuels.
- Develop verification procedures for various data.
- Improvement of QA/QC for LULUCF.
- 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 emissions.

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 the AUI on basis of information provided by the IFS on ARD and the 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 10.1.

Table 10.1. Criteria in forest definitions of the Marrakech Accord (MA), the UNEP Convention on Biological Diversity (CBD) and the Forest Resource Assessment (FAO/FRA).

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 (which is the lower limit of the MA definition). That is in agreement with the general perception in Iceland and current legitimate definitions. Only 10% of the natural birch woodland will reach 5 m height at maturity according National Forest Inventory (NFI) data. By widening the definition of forest, bigger portion of the 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 a 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.

- It includes direct human-induced activities related to emissions of greenhouse gas and/or decreases in carbon stocks on sites which have been categorized as revegetation areas and do not meet the definition of deforestation.

Hierarchy among the elected activities under Article 3.4

Revegetation is the only activity elected by Iceland under Article 3.4, hierarchy among activities is therefore not applicable.

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

Afforestation since 1990 is estimated in the NFI for Region 1 by systematic sampling of permanent plots (SSPP). The plots of the cultivated forest and in the natural birch forest will be re-measured at five and ten year intervals, respectively. Re-measurement of the cultivated forest started in 2010 and will start in 2015 for the natural birch forest. At each plot, the land use is assessed and compared to former land use. No Reforestation has been detected at the SSPP of the NFI. Although SSPP of NFI will in the future detect deforestation, special deforestation inventory aimed at deforested areas is performed together with official annual register of deforestation in accordance with the forest act (no. 3/1955) (See further description in Chapter 10.4).

Within Region 1 all cultivated forests and natural birch woodland are already mapped. The mapping of the natural birch woodland is old and remapping is ongoing and will finish in 2014. Only SSPP which are within mapped area and adjacent buffer zone are visited. The results from the NFI 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 the IFR and consequently added to the mapped area of forest land. The SSPP falling on these new area are then included in the NFI. New areas of natural birch forest following changes in land use are considerd as afforestation. Annual increase in area is found by the difference betwenn old and the new mapping survey.

Article 3.4

The SCSI is responsible for the National Inventory of Revegetation Activity (NIRA). As with the NFI 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 occurrence of activity determined (see below). At selected SSPPs (see 10.1.4 below) samples to assess relevant C-pools are 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 mapped. The SSPP falling within these new areas are then subsequently included in NIRA.

The SSPP will be revisited at five year intervals according to the original sampling plan. The NIRA started in 2007 and the first sampling phase ended in 2011. However, due to severe budget cuts at the SCSI, not all samples have been analysed to date. This delays final data submission based on the first sampling phase. In the present submission the data already available from the NIRA regarding occurrence of activity at the SSPP is used to correct the activity area. Presently the sinks and sources are estimated according to Tier 2 methods described in Chapter 7.7 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 using both existing archives and on-ground mapping. On basis of those maps the NIRA will be extended to include the revegetation activity before 1990, albeit at a coarser scale than activities since 1990. This work is estimated to be concluded in 2013.

10.1.3 *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, with emphasis mostly on activities but less on their spatial extent and some of the oldest records were lost in a house-fire. 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 for the 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 four years of the program, 932 sampling points have been selected as potential sampling points. 358 have been discarded after site visits or are still undetermined, (24%), 532 been sampled (57%), and 46 (5%) have been identified as controls. Points were randomly selected from all parts of the country in 2007 and 2008. Differences in numbers compared to last year's report are due to emphasis on covering as much of the remaining potential sampling points as possible before the end of this five years sampling period. A different approach was used in 2009, as emphasis was put on three key areas, each representing different a 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. Re-sampling of the plots established in 2007 has yet not started due to budget cuts as explained above.

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 above).

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 areas of cultivated forest. They are used, on the other hand, with an external buffer as a population for systematic sampling of permanent plots. The permanent plots are used to estimate the area of cultivated forest. For the natural birch woodlands already remapped portion (3/5) is used to estimate the total area. The area of afforestation of cultivated forest since 1990 is determined on basis of stand age within the sample plots. New afforested areas are added to the population for the SSPP annually and new sample plots falling within these areas are included in the forest inventory. The area of afforestation of natural birch forest is determined by the difference between historical mapping and current ongoing mapping (Snorrason et al. 2013).

10.2.2 Methodology Used to Develop the Land Transition Matrix

Land transition matrix was prepared based on data for activity area in the years 1990, 2008, 2009, 2010 and 2011. All revegetation activity involving tree planting are categorized from the beginning as Afforestation and reported as coming from "Other" than eligible KP categories of either article 3.3. or article 3.4. No conversion of land, previously reported under Revegetation, to Afforestation or Reforestation is occurring. All additions to the land included as 3.3 or 3.4 accordingly originate from the category other in the Land transition matrix.

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 land subjected to ARD from these maps. The proportion of the area mapped identified as cultivated forest is determined through the inspection of the IFR on the systematic sampling plots of the NFI. Geographical locations of ARD can be partially identified by the geographical distribution of the systematic sample plots identified as ARD. Deforestation, on the other hand, is mapped separately and will be fully identifiable geographically.

The land subject to Revegetation is mapped and identified in IGLUD. The area reported as Revegetation since 1990 is larger in the present submission than the area mapped as such in IGLUD. The present area estimate of revegetation activities since 1990 is an accumulation of annual estimates for the revegetation activity. Not all of these activities have been mapped and are accordingly not included in IGLUD. The mapping of the activities recorded as Farmers Revegetate the Land (FRL) activities is particularly incomplete. Excluding the FRL activity the reported activity is all within the mapped area. The SCSI is running the NIRA based on systematic sampling of plots within the mapped areas. New results from the NIRA on total activity area are reported in this year's submission. 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

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 NFI. At each plot parameters to calculate aboveground and belowground biomass are determined including tree height, diameter and number of trees inside the plot area. These parameters are then used to calculate the living biomass of trees according to species specific single tree biomass functions (Snorrason and Einarsson 2006) and measured root-to-shoot ratios (Snorrason et al. 2003). Wood removal after thinning or clear cutting has not been detected in the NFI in afforestation areas since 1990. Carbon stock losses in the living woody biomass are therefore reported as not occurring.

C-stock changes in dead wood are also based on measurements of sampling plots in the NFI. All dead wood meeting the minimum requirement of 10 cm in diameter and 1 m in length are measured and reported on the year of death as an increase of the dead wood stock. These stocks will in the future be a source of C when decomposing as the plots will be revisited and they will be remeasured and assessed in new decomposing class.

As already descriped in chapter 7.5.1, carbon stock changes of afforestation of the natural birch forest are on the other hand estimated by a country specific removal factor built on the relation between age and woody biomass C-stock of natural birch woodland.

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 significantly increasing SOC in 0-10 cm depth layer with stand age up to 50 years old stands. No significant 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 a Tier 1 methodology is applied using a default EF. The area of organic soils is determined on basis of the NNFI sampling plots. Changes in carbon stock of litter including woody debris, twigs and fine litter is estimated applying a Tier 2 methodology and CS EF.

Article 3.4

The changes in carbon stocks at revegetation sites are estimated on the basis of a country specific EF covering all carbon pools. In this submission a revised EF is used. Current, but unpublished, results from NIRA for 2007-2009 indicate considerable variation between reclamation methods and land types, as well as intrinsically lower values than previously reported. The data has not been fully analyzed, but to cover the total variability and sequestration decrease, a reduction of 10% in EF is used in this submission as suggested by SCSI. It is expected that before next submission the data will be fully analysed and new EF will be available. Built on the studies of (Aradóttir et al. 2000) the EF was assumed to be divided 10% caused by increase in living ground biomass and litter and 90% by changes in soil organic carbon.

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

Carbon stock samples of above ground biomass of other vegetation than trees are collected on field plots under the field measurement in NFI. Estimate of carbon stock changes in aboveground biomass of other vegetation than trees will be available from NFI data when sampling plots will be revisited in the period 2010-2014. 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 of larch plantations 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 as changes in the C-pool estimates of NIRA. 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 the NIRA, and will not be included until then.

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. Both AR and Revegetation have 1990 as base year. This short time window makes factoring out irrelevant.

Changes in Data and Methods since the Previous Submission (Recalculations)

The emission/removal factor and the area estimate for the Revegetation activity have been revised since last year's submission. Removals due to AR activities have also been revised. Inclusion of components not estimated in last submission and additional data on C-stock changes in the pools estimated in last submission contribute to these recalculations. See Chapter 7 for a complete list of changes.

Uncertainty Estimates

An error estimate is available for the area of afforestation of cultivated forest. The area of afforestation since 1990 is estimated at 30.30 kha (±1.69 kha 95% CL).

Uncertainty estimates for revegetation are available both for EF and area. Both are estimated with ±10% uncertainty.

Information on Other Methodological Issues

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. Cultivated forests are mostly plantations. A minority are direct seeded or self seedlings originating from cultivated forests. Afforestation of natural birch forest is estimated and reported for the first time. They are self-seeded areas in the neighbourhood of older natural forest areas. Land use has been changed in both cases 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 NFI 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 way for summer houses and roads to summer houses. There the forest removed is below the minimum area of 0.5 ha or 20 m with, no direct estimate of the effect of decrease of the C-stock is made. The permanent sample plot system of the NFI will, however, 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 the 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 7.7.

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 larger than CO_2 removal by natural birch forest (40.65 Gg CO_2) the smallest key category of level including LULUCF in the year 2011.

11 Information on accounting of Kyoto Units

11.1 Background Information

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. The AAUs have not yet been issued in the Icelandic Registry.

The Icelandic Greenhouse Gas Registry is maintained by the Environment Agency. On the 30th of June Iceland's national registry became a separate registry entity within the consolidated registries of the European Union (EU) registry. The registry holds as of 10th of April 19 EU ETS accounts, thereof 4 operator holding accounts, 9 aircraft operator holding accounts, 5 verifier accounts and 1 national holding account. Many applications for aircraft operators holding accounts are in progress.

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 Iceland has not issued its assigned amount or transferred any Kyoto Protocol units.

11.4 Publicly Accessible Information

A set of information on the registry and guidance on accessing accounts in it has been set up on the homepage of the Environment Agency, both in Icelandic (http://www.ust.is/atvinnulif/vidskiptakerfi-esb/skraningarkerfi/) and in English (aimed at foreign account holders in the EU-ETS - http://www.ust.is/the-environment-agency-of-iceland/eu-ets/registry/).

The website of the European Union Translation Log allows for the general public to access information, as referred to in decision 13/CMP.1, annex, paragraphs 44-48, about Iceland's national registry, as relevant. This link can be accessed on the homepage of EA. It can also be accessed from the website of the Union Registry:
https://ets-registry.webgate.ec.europa.eu/euregistry/Iceland/index.xhtml.

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% of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100% 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 × 18,523,847 tonnes CO_2 equivalent

= 16,671,462 tonnes CO_2 equivalent.

or,

100% of 5 × (the national total in the most recently reviewed inventory)

= 5 × 4,413,247 tonnes CO_2 equivalent

= 22,066,234 tonnes CO_2 equivalent

This means Iceland's Commitment Period Reserve is 16,671,462 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. Iceland has elected Revegetation under Article 3.4. Removals from Article 3.3 amounted to 103.164 Gg in 2008, 115.563 Gg in 2009, 135.569 Gg in 2010 and 162.343 Gg in 2011 or to 516.639 Gg in total for these four years. Removals from Article 3.4 (Net-Net accounting) amounted to 152.412 Gg in 2008, 159.595 Gg in 2009, 166.861 Gg in 2010 and 174.326 Gg or to 653.194 Gg in total for these four years. This would allow issuance of 1,169,833 RMUs (Table 11.1).

Table 11.1. Removals from activities under Article 3.3 and 3.4 and resulting RMUs.

	2008	2009	2010	2011	Total
Article 3.3 (Gg)	103.164	115.563	135.569	162.343	516.639
Article 3.4 (Gg)	152.412	159.595	166.681	174.326	653.193
RMUs (4 years of five)					**1,169,833**

11.7 Decision 14/CP.7 Accounting

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. Iceland will undertake the accounting with respect to Decision 14/CP.7 at the end of the commitment period.

Four projects fulfilled the provisions of Decision 14/CP.7 in 2008, 2009, 2010 and 2011. Further description of these projects can be found in Chapter 4.5 The total emissions fulfilling the provisions of Decision 14/CP.7 amounted to 1177 Gg in 2008, to 1201 Gg in 2009, to 1229 in 2010 and to 1209 Gg in 2011. The total emissions fulfilling the provisions of Decision 14/CP.7 for the first four year of the first commitment period under the Kyoto Protocol is therefore 5533 Gg.

Assuming the removals under Article 3.3 and 3.4 would be the same in 2012 as in 2011, a total of 1,506,501 RMUs could be issued for the first commitment period. Adding these removal units to Iceland's initial assigned amount would therefore result in total of 20,030,348 units on the assigned amount side. Assuming Iceland's emissions in 2012 would be the average of the emissions in the period 2008 to 2012, the total emissions in the period would be 23,469,781 tonnes of CO_2 equivalents. This would mean that only 3439 Gg of the emissions fulfilling the provisions of Decision 14/CP.7 would be reported separately and not be included in national totals.

12 Information on changes in national system

In June of 2012 the Icelandic Parliament passed a new law on climate change (Act 70/2012). The objectives of the Act are:

- reducing greenhouse gas emissions efficiently and effectively,
- to increase carbon sequestration from the atmosphere,
- promoting mitigation to the consequences of climate change, and
- to create conditions for the government to fulfil its international obligations in the climate of Iceland.

The law supersedes Act 65/2007 on which basis the Environment Agency made formal agreements with the necessary collaborating agencies involved in the preparation of the inventory to cover responsibilities such as data collection and methodologies, data delivery timeliness and uncertainty estimates. The data collection for this submission was based on these agreements. The articles in Act 65/2007 regarding the allocation committee still stand.

Act 70/2012 changes the form of relations between the EA and other bodies concerning data handling. Paragraph 6 of the law addresses Iceland´s greenhouse gas inventory. It states that the Environment Agency (EA) compiles Iceland´s GHG inventory in accordance with Iceland´s international obligations. The paragraph also states that the following institutions are obligated to collect data necessary for the GHG inventory and report it to the EA, further to be elaborated in regulations set by the Minister for the Environment and Natural Resources:

- Soil Conservation Service of Iceland
- Iceland Forest Service
- National Energy Authority
- Agricultural University of Iceland
- Iceland Food and Veterinary Authority
- Statistics Iceland
- The Road Traffic Directorate
- The Icelandic Recycling Fund
- Directorate of Customs

The relevant regulation regarding the manner and deadlines of said data is in preparation; a first order draft is in place. The regulation will be in place for the next inventory cycle. It is foreseen that the new law will facilitate the responsibilities, the data collection process and the timeliness.

The Coordinating Team that operated from 2008 to 2012 had the function of reviewing the emissions inventory before submission to UNFCCC as described in Chapter 1.2. The Coordinating Team led to improvements in cooperation between the different institutions involved with the inventory compilation, especially with regard to the LULUCF and Agriculture sectors. Improvements proposed by the team were incorporated into the inventory. As the prospective regulation based on Act 70/2012 formalizes the cooperation and data collection process between the EA and all responsible institutions, it takes over the role of the Coordinating Team as regards the cooperation between different institutions. The role of the Coordinating Team as regards the review will be done through external review according to prioritization plan. The external review will focus on key sources and categories where methodological changes have occured. Further all chapters will be reviewed on periodic basis. Internal review within the EA, involving experts not directly involved in the preparation of the GHG inventory, will continue. The role as regards the final review before submission to the UNFCCC will be replaced by an approval meeting with the inventory team at the EA and the director of the EA, where the emission inventory is approved before submission to the UNFCCC.

13 Information on changes in national registry

The Icelandic Greenhouse Gas Registry is maintained by the Environment Agency as before.

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and with a view to increasing efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8.

With a view to complying with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011, in addition to implementing the platform shared by the consolidating Parties, the registry of EU has undergone a major re-development. The consolidated platform which implements the national registries in a consolidated manner (including the registry of EU) is called Consolidated System of EU registries (CSEUR) and was developed together with the new EU registry on the basis the following modalities:

Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;

Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;

Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;

Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;

The transaction log and registries continue to reconcile their data with each other in order to ensure data consistency and facilitate the automated checks of the ITL;

The requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public would be fulfilled by each Party individually;

All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:

With regards to the data exchange, each national registry connects to the ITL directly and establishes a distinct and secure communication link through a consolidated communication channel (VPN tunnel);

The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;

With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;

The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries;

In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the CSEUR platform, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. During the go-live process, all relevant transaction and holdings data were migrated to the CSEUR platform and the individual connections to and from the ITL were re-established for each Party.

The following changes to the national registry of Iceland have therefore occurred in 2012, as a consequence of the transition to the CSEUR platform:

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	Registry System Administrators: Stefanía Lára Bjarnadóttir, new member. (stefania.bjarnadottir@umhverfisstofnun.is) Birna Sigrún Hallsdóttir (birna@umhverfisstofnun.is)

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	The EU Member States who are also Parties to the Kyoto Protocol (25) plus Iceland, Liechtenstein and Norway have decided to operate their registries in a consolidated manner. The Consolidated System of EU registries was certified on 1 June 2012 and went to production on 20 June 2012. A complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. This description includes: • **Readiness questionnaire** • **Application logging** **Change management procedure** **Disaster recovery** • **Manual Intervention** • **Operational Plan** • **Roles and responsibilities** • **Security Plan** • **Time Validation Plan** • **Version change Management** The documents above are provided as an appendix to this document. A new central service desk was also set up to support the registry administrators of the consolidated system. The new service desk acts as 2nd level of support to the local support provided by the Parties. It also plays a key communication role with the ITL Service Desk with regards notably to connectivity or reconciliation issues.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	In 2012, the EU registry has undergone a major redevelopment with a view to comply with the new requirements of Commission Regulation 920/2010 and Commission Regulation 1193/2011 in addition to implementing the Consolidated System of EU registries (CSEUR). The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission. During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the Data Exchange Standard (DES). All tests were executed successfully and lead to **successful certification on 1 June2012.**
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The overall change to a Consolidated System of EU Registries triggered changes the registry software and required new conformance testing. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission. During certification, the consolidated registry was notably subject to connectivity testing, connectivity reliability testing, distinctness testing and interoperability testing to demonstrate capacity and conformance to the DES. All tests were executed successfully and lead to successful certification on 1 June 2012,
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	The overall change to a Consolidated System of EU Registries also triggered changes to discrepancies procedures, as reflected in the updated **manual intervention** document and **the operational plan**. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission..

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The overall change to a Consolidated System of EU Registries also triggered changes to security, as reflected in the updated **security plan**. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	Since Iceland joined the Union Registry information have been made publicly available for the first time.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	The new internet address of the Iceland registry is: https://ets-registry.webgate.ec.europa.eu/euregistry/Iceland/index.xhtml
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	The overall change to a Consolidated System of EU Registries also triggered changes to data integrity measures, as reflected in the updated **disaster recovery plan.** The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries. The documentation is annexed to this submission.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	On 2 October 2012 a new software release (called V4) including functionalities enabling the auctioning of phase 3 and aviation allowances, a new EU ETS account type (trading account) and a trusted account list went into Production. The trusted account list adds to the set of security measures available in the CSEUR. This measure prevents any transfer from a holding account to an account that is not trusted.
The previous Annual Review recommendations	No recommendation in the 2012 draft ARR.

14 Information on minimization of adverse impacts in accordance with Article 3, Paragraph 14

No changes have been made regarding the information of adverse impact since last submission.

Figure 14.1. Summary of actions specified in Decision 15/CMP.1

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	Iceland does not have support activities in this field
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 fuels, taking into consideration the need to improve the environmental efficiency of these activities	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 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

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Annex I. KEY SOURCES

According to the IPCC definition, key sources are those that add up to 95% 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 0 lists identified key sources. Table A1 shows the level assessment of the key source analysis for 2011, 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 – 2011 level assessment.

IPCC Source category	IPCC Source category	Gas	Current Year Estimate Non-LULUCF	Current Year Estimate LULUCF	Current Year Estimate Absolute Value	Level Assess-ment without LULUCF	Cumula-tive Total of Column to left	Level Assess-ment with LULUCF	Cumula-tive Total of Column to left
				Gg					
2.C.3	Aluminium	CO2	1,214.30		1,214.30	0.275	0.275	0.180	0.180
5.B.1	Cropland remaining Cropland	CO2		1,007.98	1,007.98	0.000	0.275	0.150	0.330
1.AA.3 b	Road transport	CO2	787.51		787.51	0.178	0.454	0.117	0.447
5.C.2.5	Other land converted to Grassland, revegetation	CO2		-523.45	523.45	0.000	0.454	0.078	0.525
1.AA.4c	Fishing	CO2	500.09		500.09	0.113	0.567	0.074	0.599
2.C.2	Ferroalloys	CO2	374.42		374.42	0.085	0.652	0.056	0.654
5.C.1	Wetland drained for more than 20 years	CO2		288.41	288.41	0.000	0.652	0.043	0.697
5.A	Forest land - Afforestation	CO2		-210.03	210.03	0.000	0.652	0.031	0.728
1.AA.2	Manufacturing industry and construction	CO2	181.94		181.94	0.041	0.693	0.027	0.755
1.B.2	Geothermal energy	CO2	178.68		178.68	0.040	0.733	0.027	0.782
6.A.1	Managed waste disposal on land	CH4	146.46		146.46	0.033	0.767	0.022	0.804
4.D.1	Direct soil emissions	N2O	129.72		129.72	0.029	0.796	0.019	0.823
4.D.3	Indirect soil emissions	N2O	126.09		126.09	0.029	0.825	0.019	0.842
4.A.3	Enteric fermentation, sheep	CH4	122.31		122.31	0.028	0.852	0.018	0.860
2.F	Consumption of halocarbons and SF6, refrigeration	HFC	121.35		121.35	0.027	0.880	0.018	0.878
4.D.2	Animal production	N2O	84.15		84.15	0.019	0.899	0.012	0.890
5.G	Grassland non CO2-emissions	N2O		78.03	78.03	0.000	0.899	0.012	0.902
5.C.2.1 /2/3/4	All other conversion to Grassland	CO2		75.97	75.97	0.000	0.899	0.011	0.913
4.A.1	Enteric fermentation, cattle	CH4	72.47		72.47	0.016	0.915	0.011	0.924
5.B.2	Land converted to Cropland	CO2		64.43	64.43	0.000	0.915	0.010	0.933
2.C.3	Aluminium	PFC	63.22		63.22	0.014	0.930	0.009	0.943
4.B	Manure management	N2O	43.86		43.86	0.010	0.940	0.007	0.949
5.A	Forest land - Natural birch forest	CO2		-40.65	40.65	0.000	0.940	0.006	0.955
1.AA.3a /d	Transport	CO2	38.85		38.85	0.009	0.948	0.006	0.961
1.AA.3 b	Road transport	N2O	35.47		35.47	0.008	0.956	0.005	0.966
4.A.4-10	Enteric fermentation, rest	CH4	32.19		32.19	0.007	0.964	0.005	0.971
4.B	Manure management	CH4	29.89		29.89	0.007	0.970	0.004	0.976
6.A2	Unmanaged waste disposal sites	CH4	29.05		29.05	0.007	0.977	0.004	0.980
2.A	Mineral production	CO2	21.15		21.15	0.005	0.982	0.003	0.983
1.AA.4a /b	Residential/institutional/comm ercial	CO2	18.20		18.20	0.004	0.986	0.003	0.986
5.C.1	All other remaining Grassland	CO2		-14.14	14.14	0.000	0.986	0.002	0.988
1.AA.2	Manufacturing industry and construction	N2O	11.38		11.38	0.003	0.989	0.002	0.990
5.D	Wetlands	CO2		9.72	9.72	0.000	0.989	0.001	0.991

Table A1 continued										
IPCC Source category	**IPCC Source category**	**Gas**	**Current Year Estimate Non-LULUCF**	**Current Year Estimate LULUCF**	**Current Year Estimate Absolute Value**	**Level Assess-ment without LULUCF**	**Cumula-tive Total of Column to left**	**Level Assess-ment with LULUCF**	**Cumula-tive Total of Column to left**
				Gg					
5.D	Wetlands	CH4		8.33	8.33	0.000	0.989	0.001	0.992
6.B	Wastewater handling	N2O	7.98		7.98	0.002	0.990	0.001	0.993
6.C	Waste incineration	CO2	7.96		7.96	0.002	0.992	0.001	0.995
1.AA.1	Public electricity and heat production	CO2	6.85		6.85	0.002	0.994	0.001	0.996
1.AA.4c	Fishing	N2O	4.19		4.19	0.001	0.995	0.001	0.996
6.B	Wastewater handling	CH4	3.53		3.53	0.001	0.995	0.001	0.997
3	Solvent and other product use	N2O	3.49		3.49	0.001	0.996	0.001	0.997
1.B.2	Geothermal energy	CH4	3.37		3.37	0.001	0.997	0.001	0.998
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	3.13		3.13	0.001	0.998	0.000	0.998
3	Solvent and other product use	CO2	2.81		2.81	0.001	0.998	0.000	0.999
1.AA.3 b	Road transport	CH4	1.49		1.49	0.000	0.999	0.000	0.999
6.D	Other (composting)	N2O	1.33		1.33	0.000	0.999	0.000	0.999
5.A	Forest land - Afforestation	N2O		1.22	1.22	0.000	0.999	0.000	0.999
6.D	Other (composting)	CH4	1.20		1.20	0.000	0.999	0.000	0.999
1.AA.4c	Fishing	CH4	0.99		0.99	0.000	1.000	0.000	1.000
2.C	Metal production	CH4	0.87		0.87	0.000	1.000	0.000	1.000
5.E.2.1	Settlements	CO2		0.46	0.46	0.000	1.000	0.000	1.000
1.AA.3a /d	Transport	N2O	0.33		0.33	0.000	1.000	0.000	1.000
6.C	Waste incineration	CH4	0.29		0.29	0.000	1.000	0.000	1.000
6.C	Waste incineration	N2O	0.28		0.28	0.000	1.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH4	0.14		0.14	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	N2O	0.14		0.14	0.000	1.000	0.000	1.000
1.AA.4a /b	Residential/institutional/commercial	N2O	0.04		0.04	0.000	1.000	0.000	1.000
1.AA.3a /d	Transport	CH4	0.04		0.04	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	CH4	0.04		0.04	0.000	1.000	0.000	1.000
1.AA.4a /b	Residential/institutional/commercial	CH4	0.01		0.01	0.000	1.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	PFC	0.00		0.00	0.000	1.000	0.000	1.000
2.B	Chemical industry	CO2	0.00		0.00	0.000	1.000	0.000	1.000
2.B	Chemical industry	N2O	0.00		0.00	0.000	1.000	0.000	1.000
5.C.1	Grassland remaining grassland, biomass burning	CH4		0.00	0.00	0.000	1.000	0.000	1.000
5.C.1	Grassland remaining grassland, biomass burning	CO2		0.00	0.00	0.000	1.000	0.000	1.000
5.D	Wetlands	N2O		0.00	0.00	0.000	1.000	0.000	1.000
	Totals		**4,413.3**	**746.3**	**6,736.1**				

Table A2: Key source analysis – 1990 level assessment.

IPCC Source category	IPCC Source category	Gas	Current Year Estimate Non-LULUCF	Current Year Estimate LULUCF	Current Year Estimate Absolute Value	Level Assess-ment without LULUCF	Cumula-tive Total of Column to left	Level Assess-ment with LULUCF	Cumula-tive Total of Column to left
				Gg					
5.B.1	Cropland remaining Cropland	CO2		764.03	764.03	0.000	0.000	0.140	0.140
1.AA.4c	Fishing	CO2	655.49		655.49	0.187	0.187	0.120	0.259
1.AA.3b	Road transport	CO2	521.26		521.26	0.149	0.335	0.095	0.355
5.B.2	Land converted to Cropland	CO2		434.33	434.33	0.000	0.335	0.079	0.434
2.C.3	Aluminium	PFC	419.63		419.63	0.120	0.455	0.077	0.511
1.AA.2	Manufacturing industry and construction	CO2	360.79		360.79	0.103	0.558	0.066	0.577
5.C.2.5	Other land converted to Grassland, revegetation	CO2		-349.12	349.12	0.000	0.558	0.064	0.640
2.C.2	Ferroalloys	CO2	207.42		207.42	0.059	0.617	0.038	0.678
5.C.1	Wetland drained for more than 20 years	CO2		169.65	169.65	0.000	0.617	0.031	0.709
4.D.1	Direct soil emissions	N2O	148.85		148.85	0.042	0.659	0.027	0.737
4.A.3	Enteric fermentation, sheep	CH4	143.05		143.05	0.041	0.700	0.026	0.763
4.D.3	Indirect soil emissions	N2O	141.43		141.43	0.040	0.741	0.026	0.789
2.C.3	Aluminium	CO2	139.21		139.21	0.040	0.780	0.025	0.814
5.C.2.1/ 2/3/4	All other conversion to Grassland	CO2		127.27	127.27	0.000	0.780	0.023	0.837
6.A2	Unmanaged waste disposal sites	CH4	106.30		106.30	0.030	0.811	0.019	0.857
1.AA.3a /d	Transport	CO2	91.11		91.11	0.026	0.837	0.017	0.873
4.D.2	Animal production	N2O	89.75		89.75	0.026	0.862	0.016	0.890
4.A.1	Enteric fermentation, cattle	CH4	71.51		71.51	0.020	0.883	0.013	0.903
5.G	Grassland non CO2-emissions	N2O		68.58	68.58	0.000	0.883	0.013	0.915
1.B.2	Geothermal energy	CO2	61.36		61.36	0.017	0.900	0.011	0.927
2.A	Mineral production	CO2	52.28		52.28	0.015	0.915	0.010	0.936
4.B	Manure management	N2O	52.04		52.04	0.015	0.930	0.010	0.946
2.B	Chemical industry	N2O	48.36		48.36	0.014	0.944	0.009	0.954
1.AA.4a /b	Residential/institutional/commerci al	CO2	42.84		42.84	0.012	0.956	0.008	0.962
4.B	Manure management	CH4	30.48		30.48	0.009	0.964	0.006	0.968
4.A.4-10	Enteric fermentation, rest	CH4	29.35		29.35	0.008	0.973	0.005	0.973
5.A	Forest land - Afforestation	CO2		-28.38	28.38	0.000	0.973	0.005	0.978
1.AA.2	Manufacturing industry and construction	N2O	15.91		15.91	0.005	0.977	0.003	0.981
5.A	Forest land - Natural birch forest	CO2		-15.86	15.86	0.000	0.977	0.003	0.984
1.AA.1	Public electricity and heat production	CO2	13.64		13.64	0.004	0.981	0.002	0.987
6.A.1	Managed waste disposal on land	CH4	12.96		12.96	0.004	0.985	0.002	0.989
6.C	Waste incineration	CO2	11.27		11.27	0.003	0.988	0.002	0.991
6.B	Wastewater handling	N2O	6.23		6.23	0.002	0.990	0.001	0.992
3	Solvent and other product use	N2O	6.00		6.00	0.002	0.992	0.001	0.993
1.AA.4c	Fishing	N2O	5.51		5.51	0.002	0.993	0.001	0.994
6.C	Waste incineration	CH4	5.19		5.19	0.001	0.995	0.001	0.995
1.AA.3b	Road transport	N2O	4.54		4.54	0.001	0.996	0.001	0.996
3	Solvent and other product use	CO2	3.07		3.07	0.001	0.997	0.001	0.997
1.AA.3b	Road transport	CH4	2.96		2.96	0.001	0.998	0.001	0.997

Table A2 continued									
IPCC Source category	IPCC Source category	Gas	Current Year Estimate Non-LULUCF	Current Year Estimate LULUCF	Current Year Estimate Absolute Value	Level Assess-ment without LULUCF	Cumula-tive Total of Column to left	Level Assess-ment with LULUCF	Cumula-tive Total of Column to left
				Gg					
5.C.1	All other remaining Grassland	CO2		-2.86	2.86	0.000	0.998	0.001	0.998
5.D	Wetlands	CO2		1.86	1.86	0.000	0.998	0.000	0.998
5.D	Wetlands	CH4		1.60	1.60	0.000	0.998	0.000	0.998
6.B	Wastewater handling	CH4	1.41		1.41	0.000	0.998	0.000	0.999
6.C	Waste incineration	N2O	1.39		1.39	0.000	0.998	0.000	0.999
1.AA.4c	Fishing	CH4	1.31		1.31	0.000	0.999	0.000	0.999
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	1.15		1.15	0.000	0.999	0.000	0.999
1.AA.3a /d	Transport	N2O	0.77		0.77	0.000	0.999	0.000	1.000
1.B.2	Geothermal energy	CH4	0.68		0.68	0.000	1.000	0.000	1.000
2.C	Metal production	CH4	0.61		0.61	0.000	1.000	0.000	1.000
2.B	Chemical industry	CO2	0.36		0.36	0.000	1.000	0.000	1.000
5.A	Forest land - Afforestation	N2O		0.31	0.31	0.000	1.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH4	0.25		0.25	0.000	1.000	0.000	1.000
1.AA.3a /d	Transport	CH4	0.12		0.12	0.000	1.000	0.000	1.000
1.AA.4a /b	Residential/institutional/commercial	N2O	0.10		0.10	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	N2O	0.02		0.02	0.000	1.000	0.000	1.000
1.AA.4a /b	Residential/institutional/commercial	CH4	0.02		0.02	0.000	1.000	0.000	1.000
1.AA.1	Public electricity and heat production	CH4	0.01		0.01	0.000	1.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	HFC	0.00		0.00	0.000	1.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	PFC	0.00		0.00	0.000	1.000	0.000	1.000
5.C.1	Grassland remaining grassland, biomass burning	CH4		0.00	0.00	0.000	1.000	0.000	1.000
5.C.1	Grassland remaining grassland, biomass burning	CO2		0.00	0.00	0.000	1.000	0.000	1.000
5.D	Wetlands	N2O		0.00	0.00	0.000	1.000	0.000	1.000
5.E.2.1	Settlements	CO2		0.00	0.00	0.000	1.000	0.000	1.000
6.D	Other (composting)	CH4	0.00		0.00	0.000	1.000	0.000	1.000
6.D	Other (composting)	N2O	0.00		0.00	0.000	1.000	0.000	1.000
	Totals		**3,508.0**	**1,171.4**	**5,471.9**				

Table A3: Key source analysis – trend assessment.

IPCC Source category	IPCC Source category	Gas	Base Year Estimate	Current Year Estimate	Absolute Estimate	Level Assess-ment	Trend Assess-ment	Contribu tion to Trend	Cumula-tive Total
				Gg					
2.C.3	Aluminium	CO2	139.21	1,214.30	1,214.30	0.180	0.143	0.255	0.255
5.B.2	Land converted to Cropland	CO2	434.33	64.43	64.43	0.010	0.056	0.099	0.354
2.C.3	Aluminium	PFC	419.63	63.22	63.22	0.009	0.054	0.096	0.450
1.AA.4c	Fishing	CO2	655.49	500.09	500.09	0.074	0.030	0.053	0.504
1.AA.2	Manufacturing industry and construction	CO2	360.79	181.94	181.94	0.027	0.029	0.052	0.555
1.AA.3b	Road transport	CO2	521.26	787.51	787.51	0.117	0.029	0.051	0.606
5.A	Forest land - Afforestation	CO2	-28.38	-210.03	210.03	0.031	0.024	0.043	0.649
5.B.1	Cropland remaining Cropland	CO2	764.03	1,007.98	1,007.98	0.150	0.022	0.040	0.689
2.C.2	Ferroalloys	CO2	207.42	374.42	374.49	0.056	0.020	0.035	0.724
5.C.2.5	Other land converted to Grassland, revegetation	CO2	-349.12	-523.45	523.45	0.078	0.019	0.033	0.757
6.A.1	Managed waste disposal on land	CH4	12.96	146.46	146.46	0.022	0.018	0.032	0.789
2.F	Consumption of halocarbons and SF6, refrigeration	HFC	0.00	121.35	121.35	0.018	0.016	0.029	0.818
1.B.2	Geothermal energy	CO2	61.36	178.68	178.68	0.027	0.015	0.027	0.845
5.C.1	Wetland drained for more than 20 years	CO2	169.65	288.41	288.41	0.043	0.014	0.024	0.869
6.A2	Unmanaged waste disposal sites	CH4	106.30	29.05	29.05	0.004	0.012	0.021	0.890
5.C.2.1/ 2/3/4	All other conversion to Grassland	CO2	127.27	75.97	75.97	0.011	0.009	0.015	0.906
1.AA.3a /d	Transport	CO2	91.11	38.85	38.85	0.006	0.008	0.015	0.921
2.A	Mineral production	CO2	52.28	21.15	21.15	0.003	0.005	0.009	0.929
4.A.3	Enteric fermentation, sheep	CH4	143.05	122.31	122.31	0.018	0.005	0.009	0.938
4.D.1	Direct soil emissions	N2O	148.85	129.72	129.72	0.019	0.005	0.008	0.946
1.AA.3b	Road transport	N2O	4.54	35.47	35.47	0.005	0.004	0.007	0.953
4.D.3	Indirect soil emissions	N2O	141.43	126.09	126.09	0.019	0.004	0.007	0.961
1.AA.4a /b	Residential/institutional/commerci al	CO2	42.84	18.20	18.20	0.003	0.004	0.007	0.968
5.A	Forest land - Natural birch forest	CO2	-15.86	-40.65	40.65	0.006	0.003	0.006	0.973
4.D.2	Animal production	N2O	89.75	84.15	84.15	0.012	0.002	0.004	0.977
4.B	Manure management	N2O	52.04	43.86	43.86	0.007	0.002	0.003	0.980
5.C.1	All other remaining Grassland	CO2	-2.86	-14.14	14.14	0.002	0.001	0.003	0.983
1.AA.1	Public electricity and heat production	CO2	13.64	6.85	6.85	0.001	0.001	0.002	0.984
5.D	Wetlands	CO2	1.86	9.72	9.72	0.001	0.001	0.002	0.986
5.D	Wetlands	CH4	1.60	8.33	8.33	0.001	0.001	0.002	0.988
4.A.1	Enteric fermentation, cattle	CH4	71.51	72.47	72.47	0.011	0.001	0.002	0.989
1.AA.2	Manufacturing industry and construction	N2O	15.91	11.38	11.38	0.002	0.001	0.001	0.991
6.C	Waste incineration	CH4	5.19	0.29	0.29	0.000	0.001	0.001	0.992
6.C	Waste incineration	CO2	11.27	7.96	7.96	0.001	0.001	0.001	0.993

Table A3 continued									
IPCC Source category	**IPCC Source category**	**Gas**	**Base Year Estimate**	**Current Year Estimate**	**Absolute Estimate**	**Level Assess-ment**	**Trend Assess-ment**	**Contribu tion to Trend**	**Cumulati ve Total**
				Gg					
4.B	Manure management	CH4	30.48	29.89	29.89	0.004	0.001	0.001	0.994
3	Solvent and other product use	N2O	6.00	3.49	3.49	0.001	0.000	0.001	0.995
1.B.2	Geothermal energy	CH4	0.68	3.37	3.37	0.001	0.000	0.001	0.996
5.G	Grassland non CO2-emissions	N2O	68.58	78.03	78.03	0.012	0.000	0.001	0.996
6.B	Wastewater handling	CH4	1.41	3.53	3.53	0.001	0.000	0.000	0.997
1.AA.4c	Fishing	N2O	5.51	4.19	4.19	0.001	0.000	0.000	0.997
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	1.15	3.13	3.13	0.000	0.000	0.000	0.998
1.AA.3b	Road transport	CH4	2.96	1.49	1.49	0.000	0.000	0.000	0.998
6.D	Other (composting)	N2O	0.00	1.33	1.33	0.000	0.000	0.000	0.998
6.C	Waste incineration	N2O	1.39	0.28	0.28	0.000	0.000	0.000	0.999
6.D	Other (composting)	CH4	0.00	1.20	1.20	0.000	0.000	0.000	0.999
6.B	Wastewater handling	N2O	6.23	7.98	7.98	0.001	0.000	0.000	0.999
5.A	Forest land - Afforestation	N2O	0.31	1.22	1.22	0.000	0.000	0.000	0.999
3	Solvent and other product use	CO2	3.07	2.81	2.81	0.000	0.000	0.000	0.999
1.AA.3a /d	Transport	N2O	0.77	0.33	0.33	0.000	0.000	0.000	1.000
5.E.2.1	Settlements	CO2	0.00	0.46	0.46	0.000	0.000	0.000	1.000
1.AA.4c	Fishing	CH4	1.31	0.99	0.99	0.000	0.000	0.000	1.000
2.C	Metal production	CH4	0.61	0.87	0.87	0.000	0.000	0.000	1.000
4.A.4-10	Enteric fermentation, rest	CH4	29.35	32.19	32.19	0.005	0.000	0.000	1.000
1.AA.2	Manufacturing industry and construction	CH4	0.25	0.14	0.14	0.000	0.000	0.000	1.000
1.AA.1	Public electricity and heat production	N2O	0.02	0.14	0.14	0.000	0.000	0.000	1.000
1.AA.3a /d	Transport	CH4	0.12	0.04	0.04	0.000	0.000	0.000	1.000
1.AA.4a /b	Residential/institutional/commerci al	N2O	0.10	0.04	0.04	0.000	0.000	0.000	1.000
1.AA.1	Public electricity and heat production	CH4	0.01	0.04	0.04	0.000	0.000	0.000	1.000
1.AA.4a /b	Residential/institutional/commerci al	CH4	0.02	0.01	0.01	0.000	0.000	0.000	1.000
2.F	Consumption of halocarbons and SF6, refrigeration	PFC	0.00	0.00	0.00	0.000	0.000	0.000	1.000
2.B	Chemical industry	CO2	0.36	0.00	0.00	0.000		0.000	1.000
2.B	Chemical industry	N2O	48.36	0.00	0.00	0.000		0.000	1.000
5.C.1	Grassland remaining grassland, biomass burning	CH4	0.00	0.00	0.00	0.000		0.000	1.000
5.C.1	Grassland remaining grassland, biomass burning	CO2	0.00	0.00	0.00	0.000		0.000	1.000
5.D	Wetlands	N2O	0.00	0.00	0.00	0.000		0.000	1.000
	Totals		**4,679.4**	**5,159.6**	**6,736.1**		**0.561**	**1.000**	

ANNEX II. QUANTITATIVE UNCERTAINTY (including LULUCF)

IPCC Source category	IPCC Source category	Gas	Base year emis-sions (1990)	Year t emis-sions (2011)	Activity data uncert-ainty	Emission factor uncert-ainty	Com-bined uncert-ainty	Com-bined uncert. (% of total national emis-sions in year 2011)	Type A sensi-tivity	Type B sensi-tivity	Uncert. in emission trend intro-duced by EF uncert-ainty	Uncert. in emission trend intro-duced by AD uncert-ainty	Uncert. Intro-duced into the trend in total national emis-sions
			Gg	Gg	%	%	%	%					%
1.AA.1	Public electricity and heat production	CO2	13.6	6.8	5.0	5.0	7.1	0.009	-0.002	0.001	-0.009	0.010	0.014
1.AA.1	Public electricity and heat production	CH4	0.0	0.0	5.0	100.0	100.1	0.001	0.000	0.000	0.001	0.000	0.001
1.AA.1	Public electricity and heat production	N2O	0.0	0.1	5.0	150.0	150.1	0.004	0.000	0.000	0.004	0.000	0.004
1.AA.2	Manufacturing industry and construction	CO2	360.8	181.9	5.0	5.0	7.1	0.249	-0.046	0.039	-0.230	0.275	0.359
1.AA.2	Manufacturing industry and construction	CH4	0.3	0.1	5.0	100.0	100.1	0.003	0.000	0.000	-0.003	0.000	0.003
1.AA.2	Manufacturing industry and construction	N2O	15.9	11.4	5.0	150.0	150.1	0.331	-0.001	0.002	-0.197	0.017	0.198
1.AA.3a /d	Transport	CO2	91.1	38.8	5.0	5.0	7.1	0.053	-0.013	0.008	-0.066	0.059	0.088
1.AA.3a /d	Transport	CH4	0.1	0.0	5.0	100.0	100.1	0.001	0.000	0.000	-0.002	0.000	0.002
1.AA.3a /d	Transport	N2O	0.8	0.3	5.0	200.0	200.1	0.013	0.000	0.000	-0.022	0.001	0.022
1.AA.3b	Road transport	CO2	521.3	787.5	5.0	5.0	7.1	1.080	0.045	0.168	0.227	1.190	1.212
1.AA.3b	Road transport	CH4	3.0	1.5	5.0	40.0	40.3	0.012	0.000	0.000	-0.015	0.002	0.015
1.AA.3b	Road transport	N2O	4.5	35.5	5.0	50.0	50.2	0.346	0.007	0.008	0.325	0.054	0.330

1.AA.4a /b	Residential/institutional/commercial	CO2	42.8	18.2	5.0	5.0	7.1	0.025	-0.006	0.004	-0.031	0.028	0.041
1.AA.4a /b	Residential/institutional/commercial	CH4	0.0	0.0	5.0	100.0	100.1	0.000	0.000	0.000	0.000	0.000	0.000
1.AA.4a /b	Residential/institutional/commercial	N2O	0.1	0.0	5.0	150.0	150.1	0.001	0.000	0.000	-0.002	0.000	0.002
1.AA.4c	Fishing	CO2	655.5	500.1	3.0	5.0	5.8	0.565	-0.047	0.107	-0.237	0.453	0.512
1.AA.4c	Fishing	CH4	1.3	1.0	3.0	100.0	100.0	0.019	0.000	0.000	-0.010	0.001	0.010
1.AA.4c	Fishing	N2O	5.5	4.2	3.0	150.0	150.0	0.122	0.000	0.001	-0.060	0.004	0.060
1.B.2	Geothermal energy	CO2	61.4	178.7	6.0	8.0	10.0	0.347	0.024	0.038	0.190	0.324	0.376
1.B.2	Geothermal energy	CH4	0.7	3.4	6.0	8.0	10.0	0.007	0.001	0.001	0.004	0.006	0.008
2.A	Mineral production	CO2	52.3	21.1	5.0	6.5	8.2	0.034	-0.008	0.005	-0.051	0.032	0.060
2.B	Chemical industry	CO2	0.4		3.0	1.0	3.2	0.000	0.000	0.000	0.000	0.000	0.000
2.B	Chemical industry	N2O	48.4		30.0	40.0	50.0	0.000	-0.011	0.000	-0.455	0.000	0.455
2.C	Metal production	CH4	0.6	0.9	1.5	100.0	100.0	0.017	0.000	0.000	0.004	0.000	0.004
2.C.2	Ferroalloys	CO2	207.4	374.4	1.5	1.0	1.8	0.131	0.031	0.080	0.031	0.170	0.173
2.C.3	Aluminium	CO2	139.2	1,214.3	1.0	1.5	1.8	0.425	0.227	0.259	0.340	0.367	0.500
2.C.3	Aluminium	PFC	419.6	63.2	0.0	9.3	9.3	0.114	-0.085	0.014	-0.793	0.000	0.793
2.F	Consumption of halocarbons and SF6, refrigeration	HFC		121.4	176.0	129.8	218.7	5.146	0.026	0.026	3.365	6.455	7.280
2.F	Consumption of halocarbons and SF6, refrigeration	PFC		0.0	176.0	129.8	218.7	0.000	0.000	0.000	0.000	0.000	0.000
2.F	Consumption of halocarbons and SF6, electrical equipment	SF6	1.1	3.1	20.0	50.0	53.9	0.033	0.000	0.001	0.020	0.019	0.027
3	Solvent and other product use	N2O	6.0	3.5	20.0	5.0	20.6	0.014	-0.001	0.001	-0.003	0.021	0.021
3	Solvent and other product use	CO2	3.1	2.8	59.6	613.0	615.9	0.336	0.000	0.001	-0.075	0.051	0.090
4.A.1	Enteric fermentation, cattle	CH4	71.5	72.5	24.6	20.0	31.7	0.446	-0.001	0.015	-0.027	0.539	0.540
4.A.3	Enteric fermentation, sheep	CH4	143.1	122.3	27.4	20.0	33.9	0.804	-0.008	0.026	-0.151	1.011	1.022
4.A.4-10	Enteric fermentation, rest	CH4	29.3	32.2	20.0	40.0	44.7	0.279	0.000	0.007	-0.001	0.195	0.195

4.B	Manure management	N2O	52.0	43.9	56.1	100.0	114.7	0.975	-0.003	0.009	-0.288	0.744	0.798
4.B	Manure management	CH4	30.5	29.9	50.9	126.9	136.7	0.792	-0.001	0.006	-0.100	0.460	0.471
4.D.1	Direct soil emissions	N2O	148.9	129.7	31.8	400.0	401.3	10.095	-0.007	0.028	-2.932	1.248	3.187
4.D.2	Animal production	N2O	89.7	84.2	55.8	100.0	114.5	1.869	-0.003	0.018	-0.315	1.419	1.454
4.D.3	Indirect soil emissions	N2O	141.4	126.1	66.9	1,000.0	1,002.2	24.508	-0.006	0.027	-6.357	2.551	6.850
5.A	Forest land - Natural birch forest	CO2	-15.9	-40.6	14.0	10.0	17.2	-0.136	-0.005	-0.009	-0.050	-0.172	0.179
5.A	Forest land - Afforestation	CO2	-28.4	-210.0	5.0	10.0	11.2	-0.455	-0.038	-0.045	-0.382	-0.317	0.497
5.A	Forest land - Afforestation	N2O	0.3	1.2	5.0	400.0	400.0	0.095	0.000	0.000	0.075	0.002	0.075
5.B.1	Cropland remaining Cropland	CO2	764.0	1,008.0	20.0	90.0	92.2	18.022	0.035	0.215	3.189	6.093	6.877
5.B.2	Land converted to Cropland	CO2	434.3	64.4	20.0	90.0	92.2	1.152	-0.088	0.014	-7.959	0.389	7.968
5.C.1	Wetland drained for more than 20 years	CO2	169.6	288.4	20.0	90.0	92.2	5.157	0.022	0.062	1.951	1.743	2.616
5.C.1	All other remaining Grassland	CO2	-2.9	-14.1	20.0	20.0	28.3	-0.078	-0.002	-0.003	-0.047	-0.085	0.098
5.C.1	Grassland remaining grassland, biomass burning	CH4					0.0	0.000	0.000	0.000	0.000	0.000	0.000
5.C.1	Grassland remaining grassland, biomass burning	CO2					0.0	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.1/ 2/3/4	All other conversion to Grassland	CO2	127.3	76.0	20.0	90.0	92.2	1.358	-0.014	0.016	-1.236	0.459	1.319
5.C.2.5	Other land converted to Grassland, revegetation	CO2	-349.1	-523.4	30.0	25.0	39.1	-3.964	-0.030	-0.112	-0.742	-4.746	4.803
5.D	Wetlands	CO2	1.9	9.7	20.0	50.0	53.9	0.102	0.002	0.002	0.082	0.059	0.101
5.D	Wetlands	CH4	1.6	8.3	20.0	50.0	53.9	0.087	0.001	0.002	0.070	0.050	0.086
5.D	Wetlands	N2O					0.0	0.000	0.000	0.000	0.000	0.000	0.000
5.E.2.1	Settlements	CO2		0.5	5.0	10.0	11.2	0.001	0.000	0.000	0.001	0.001	0.001
5.G	Grassland non CO2-emissions	N2O	68.6	78.0	20.0	25.0	32.0	0.484	0.001	0.017	0.013	0.472	0.472
6.A.1	Managed waste disposal on land	CH4	13.0	146.5	42.4	35.9	55.6	1.578	0.028	0.031	1.013	1.878	2.134
6.A2	Unmanaged waste disposal sites	CH4	106.3	29.1	42.4	57.2	71.2	0.401	-0.019	0.006	-1.077	0.372	1.140
6.B	Wastewater handling	CH4	1.4	3.5	36.4	58.3	68.7	0.047	0.000	0.001	0.025	0.039	0.046

6.B	Wastewater handling	N2O	6.2	8.0	45.7	1,000.0	1,001.0	1.549	0.000	0.002	0.239	0.110	0.263
6.C	Waste incineration	CO2	11.3	8.0	33.9	13.8	36.6	0.056	-0.001	0.002	-0.013	0.081	0.082
6.C	Waste incineration	N2O	1.4	0.3	20.0	100.0	102.0	0.006	0.000	0.000	-0.027	0.002	0.027
6.C	Waste incineration	CH4	5.2	0.3	20.0	100.0	102.0	0.006	-0.001	0.000	-0.116	0.002	0.116
6.D	Other (composting)	CH4		1.2	20.0	13,233.3	13,233.3	3.079	0.000	0.000	3.392	0.007	3.392
6.D	Other (composting)	N2O		1.3	20.0	400.0	400.5	0.103	0.000	0.000	0.114	0.008	0.114
	Totals		**4,679.4**	**5,156.5**			**Uncertainty of emissions:**	**33.5**				**Trend uncertainty:**	**16.7**

ANNEX III. Explanation of EA'S adjustment of date on fuel sales by sector

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

No.	Category	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes
Gas/Diesel Oil															
10X40	house heating and swimming pools	10,623	8,535	7,625	6,349	5,756	3,665	4,428	4,240	2,417	2,420	1,546	1,626	1,637	1,595
10X5X	industry	5,072	1,129	8,920	9,443	10,233	22,762	24,995	15,196	15,455	12,819	7,217	9,100	6,663	3,783
10X60	energy industries	1,300	1,091	1,065	897	1,112	631	112	21	1,349	1,109	1,436	760	1,012	683
10X90	other	0	458	1,386	1,323	756	1,832	8,124	8,928	8,296	2,033	1,336	1,499	2,728	1,136
Residual Fuel Oil															
10840	house heating and swimming pools	2,989	3,079	122	162	203	118	37	195	76	86	63	78	0	0
1085X	industry	55,895	56,172	46,146	55,782	64,026	48,547	28,230	25,005	23,635	22,708	19,562	17,646	14,917	16,514
10860	energy industries	0	0	-53	0	23	0	0	0	5	4,498	0	0	0	0
10890	other	39	52	67	4,978	6,465	319	6,139	0	0	131	913	0	1,629	780

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

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

NEA has estimated the fuel use by swimming pools (**1A4a**). These values are subtracted from the adjusted 10X40 category. The rest of the category is then **1A4c** – Residential.

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

	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Swimming pools	1,800	1,600	1,600	1,400	1,400	1,200	1,100	1,000	300	300	300	300	300	300

For Residual Fuel Oil:
The sectors 10840 and 10860 are added together. This is the fuel use by **1A1a** - public heat plants, In year 1997 four tonnes are subtracted from this category as the category 10890 has minus four tonnes, leaving category 10890 with 0 in 1997. The categories 1085X Industry and 10890 Other are added together, this is the fuel use in **1A2** – industry.

ANNEX IV. CRF Table Summary 2 for 1990-2011

1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2013 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)	**3,261.02**	**407.80**	**589.79**	**NA,NE,NO**	**419.63**	**1.15**	**4,679.39**
1. Energy	**1,746.49**	**5.35**	**26.86**				**1,778.70**
A. Fuel Combustion (Sectoral Approach)	1,685.13	4.67	26.86				1,716.66
1. Energy Industries	13.64	0.01	0.02				13.67
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	698.33	1.33	5.61				705.27
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	61.36	0.68	NA,NO				62.04
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	61.36	0.68	NA,NO				62.04
2. Industrial Processes	**399.28**	**0.61**	**48.36**	**NA,NE,NO**	**419.63**	**1.15**	**869.03**
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	346.63	0.61	NA	NA,NE,NO	419.63	NA,NO	766.88
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)				NA,NO	NA,NO	1.15	1.15
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.07**		**6.00**				**9.07**
4. Agriculture		**274.38**	**432.07**				**706.45**
A. Enteric Fermentation		243.90					243.90
B. Manure Management		30.48	52.04				82.51
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE,NO	380.03				380.03
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)	**1,100.91**	**1.60**	**68.89**				**1,171.40**
A. Forest Land	-44.24	NE,NO	0.31				-43.93
B. Cropland	1,198.36	NE,NO	IE,NA,NE,NO				1,198.36
C. Grassland	-55.06	NE,NO	NE,NO				-55.06
D. Wetlands	1.86	1.60	NA,NO				3.46
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	68.58				68.58
6. Waste	**11.27**	**125.86**	**7.61**				**144.75**
A. Solid Waste Disposal on Land	NA,NE	119.25					119.25
B. Waste-water Handling		1.41	6.23				7.64
C. Waste Incineration	11.27	5.19	1.39				17.86
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	3,507.99
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,679.39

(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.

1991

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2013 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)]	**3,186.77**	**409.50**	**570.80**	**NA,NE,NO**	**348.34**	**1.30**	**4,516.71**
1. Energy	**1,710.48**	**5.40**	**26.31**				**1,742.20**
A. Fuel Combustion (Sectoral Approach)	1,640.53	4.80	26.31				1,671.65
1. Energy Industries	15.22	0.01	0.02				15.25
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	715.83	1.36	5.75				722.95
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	69.95	0.60	NA,NO				70.55
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	69.95	0.60	NA,NO				70.55
2. Industrial Processes	**365.29**	**0.51**	**46.81**	**NA,NE,NO**	**348.34**	**1.30**	**762.25**
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	316.32	0.51	NA	NA,NE,NO	348.34	NA,NO	665.17
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)]				NA,NO	NA,NO	1.30	1.30
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**5.43**				**8.63**
4. Agriculture		**266.72**	**415.44**				**682.15**
A. Enteric Fermentation		236.58					236.58
B. Manure Management		30.13	48.33				78.46
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	367.11				367.11
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)]	**1,096.61**	**6.31**	**69.11**				**1,172.04**
A. Forest Land	-46.01	NE,NO	0.37				-45.64
B. Cropland	1,193.22	NE,NO	IE,NA,NE,NO				1,193.22
C. Grassland	-57.96	NE,NO	NE,NO				-57.96
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	68.74				68.74
6. Waste	**11.18**	**130.56**	**7.70**				**149.44**
A. Solid Waste Disposal on Land	NA,NE	123.25					123.25
B. Waste-water Handling		2.15	6.32				8.47
C. Waste Incineration	11.18	5.16	1.38				17.72
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)]	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
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	3,344.68
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,516.71

(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.

1992

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Inventory 1992
Submission 2013 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]	**3,297.15**	**413.65**	**539.86**	**NA,NE,NO**	**155.28**	**1.30**	**4,407.24**
1. Energy	**1,833.72**	**5.67**	**26.03**				**1,865.42**
A. Fuel Combustion (Sectoral Approach)	1,766.11	5.03	26.03				1,797.17
1. Energy Industries	13.67	0.01	0.02				13.70
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	778.72	1.49	6.29				786.49
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	67.62	0.63	NA,NO				68.25
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	67.62	0.63	NA,NO				68.25
2. Industrial Processes	**368.30**	**0.53**	**41.85**	**NA,NE,NO**	**155.28**	**1.30**	**567.26**
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	322.36	0.53	NA	NA,NE,NO	155.28	NA,NO	478.16
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]				NA,NO	NA,NO	1.30	1.30
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**4.82**				**8.02**
4. Agriculture		**260.82**	**390.06**				**650.88**
A. Enteric Fermentation		231.92					231.92
B. Manure Management		28.90	43.06				71.96
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [3]		NA,NE,NO	347.00				347.00
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]	**1,081.04**	**6.31**	**69.36**				**1,156.72**
A. Forest Land	-51.10	NE,NO	0.45				-50.66
B. Cropland	1,187.35	NE,NO	IE,NA,NE,NO				1,187.35
C. Grassland	-62.57	NE,NO	NE,NO				-62.57
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	68.91				68.91
6. Waste	**10.88**	**140.33**	**7.74**				**158.95**
A. Solid Waste Disposal on Land	NA,NE	133.12					133.12
B. Waste-water Handling		2.17	6.39				8.56
C. Waste Incineration	10.88	5.03	1.35				17.26
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	3,250.52
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,407.24

(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.

1993

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Inventory 1993
Submission 2013 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)]	**3,406.97**	**421.70**	**550.70**	**0.67**	**74.86**	**1.30**	**4,456.21**
1. Energy	**1,910.14**	**5.76**	**27.52**				**1,943.42**
A. Fuel Combustion (Sectoral Approach)	1,824.76	5.11	27.52				1,857.40
1. Energy Industries	14.87	0.02	0.09				14.98
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	808.43	1.56	6.55				816.54
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	85.38	0.65	NA,NO				86.02
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	85.38	0.65	NA,NO				86.02
2. Industrial Processes	**416.72**	**0.60**	**44.02**	**0.67**	**74.86**	**1.30**	**538.18**
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	376.80	0.60	NA	NA,NE,NO	74.86	NA,NO	452.26
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,NO	1.30	1.98
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.21**		**4.74**				**7.96**
4. Agriculture		**260.75**	**397.25**				**658.00**
A. Enteric Fermentation		231.97					231.97
B. Manure Management		28.79	43.74				72.53
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	353.51				353.51
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)]	**1,067.63**	**6.31**	**69.54**				**1,143.49**
A. Forest Land	-56.33	NE,NO	0.46				-55.87
B. Cropland	1,181.43	NE,NO	IE,NA,NE,NO				1,181.43
C. Grassland	-64.82	NE,NO	NE,NO				-64.82
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.08				69.08
6. Waste	**9.27**	**148.27**	**7.63**				**165.17**
A. Solid Waste Disposal on Land	NA,NE	141.72					141.72
B. Waste-water Handling		2.19	6.46				8.66
C. Waste Incineration	9.27	4.36	1.17				14.80
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	3,312.72
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,456.21

(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.

1994

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2013 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)]	**3,341.33**	**430.39**	**556.88**	**1.41**	**44.57**	**1.30**	**4,375.89**
1. Energy	**1,857.28**	**5.75**	**27.69**				**1,890.72**
A. Fuel Combustion (Sectoral Approach)	1,787.16	5.10	27.69				1,819.94
1. Energy Industries	14.54	0.02	0.09				14.65
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	791.04	1.52	6.45				799.00
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	70.12	0.66	NA,NO				70.78
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	70.12	0.66	NA,NO				70.78
2. Industrial Processes	**417.92**	**0.57**	**44.33**	**1.41**	**44.57**	**1.30**	**510.10**
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	380.20	0.57	NA	NA,NE,NO	44.57	NA,NO	425.34
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)]				1.41	NA,NO	1.30	2.71
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.20**		**4.29**				**7.49**
4. Agriculture		**261.77**	**403.27**				**665.04**
A. Enteric Fermentation		233.27					233.27
B. Manure Management		28.50	43.78				72.28
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	359.49				359.49
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)]	**1,054.39**	**6.31**	**69.72**				**1,130.42**
A. Forest Land	-59.22	NE,NO	0.47				-58.75
B. Cropland	1,175.47	NE,NO	IE,NA,NE,NO				1,175.47
C. Grassland	-69.22	NE,NO	NE,NO				-69.22
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.24				69.24
6. Waste	**8.54**	**155.99**	**7.59**				**172.11**
A. Solid Waste Disposal on Land	NA,NE	149.73					149.73
B. Waste-water Handling		2.21	6.50				8.71
C. Waste Incineration	8.54	4.05	1.08				13.67
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	3,245.47
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,375.89

(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.

1995

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2013 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)]	**3,350.67**	**428.23**	**547.43**	**8.51**	**58.84**	**1.30**	**4,394.99**
1. Energy	**1,872.78**	**5.32**	**38.15**				**1,916.25**
A. Fuel Combustion (Sectoral Approach)	1,790.55	4.58	38.15				1,833.28
1. Energy Industries	18.89	0.03	0.12				19.04
2. Manufacturing Industries and Construction	358.10	0.27	19.29				377.67
3. Transport	613.50	2.73	12.20				628.43
4. Other Sectors	800.06	1.54	6.54				808.14
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	82.23	0.74	NA,NO				82.97
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	82.23	0.74	NA,NO				82.97
2. Industrial Processes	**434.70**	**0.59**	**42.16**	**8.51**	**58.84**	**1.30**	**546.11**
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	396.37	0.59	NA	NA,NE,NO	58.84	NA,NO	455.81
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)]				8.51	NA,NO	1.30	9.82
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.21**		**4.29**				**7.51**
4. Agriculture		**252.12**	**385.11**				**637.23**
A. Enteric Fermentation		224.14					224.14
B. Manure Management		27.98	41.02				69.00
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	344.09				344.09
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)]	**1,032.44**	**6.31**	**70.01**				**1,108.77**
A. Forest Land	-69.33	NE,NO	0.52				-68.81
B. Cropland	1,169.54	NE,NO	IE,NA,NE,NO				1,169.54
C. Grassland	-75.12	NE,NO	NE,NO				-75.12
D. Wetlands	7.36	6.31	NA,NO				13.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.49				69.49
6. Waste	**7.53**	**163.88**	**7.71**				**179.12**
A. Solid Waste Disposal on Land	NA,NE	157.88					157.88
B. Waste-water Handling		2.22	6.56				8.77
C. Waste Incineration	7.53	3.61	0.97				12.11
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	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	3,286.22
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,394.99

(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.

1996

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2013 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)]	**3,425.98**	**436.58**	**568.39**	**15.31**	**25.15**	**1.30**	**4,472.72**
1. Energy	**1,963.14**	**5.46**	**38.08**				**2,006.67**
A. Fuel Combustion (Sectoral Approach)	1,881.87	4.75	38.08				1,924.70
1. Energy Industries	11.62	0.03	0.13				11.78
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	866.82	1.66	7.06				875.54
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	81.27	0.70	NA,NO				81.97
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	81.27	0.70	NA,NO				81.97
2. Industrial Processes	**434.07**	**0.57**	**49.29**	**15.31**	**25.15**	**1.30**	**525.70**
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	391.89	0.57	NA	NA,NE,NO	25.15	NA,NO	417.61
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)]				15.31	NA,NO	1.30	16.61
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.45**		**4.71**				**8.16**
4. Agriculture		**255.88**	**398.39**				**654.28**
A. Enteric Fermentation		227.36					227.36
B. Manure Management		28.52	42.01				70.53
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	356.38				356.38
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)]	**1,018.57**	**7.70**	**70.25**				**1,096.51**
A. Forest Land	-74.12	NE,NO	0.54				-73.58
B. Cropland	1,163.64	NE,NO	IE,NA,NE,NO				1,163.64
C. Grassland	-79.93	NE,NO	NE,NO				-79.93
D. Wetlands	8.98	7.70	NA,NO				16.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	69.71				69.71
6. Waste	**6.75**	**166.97**	**7.67**				**181.39**
A. Solid Waste Disposal on Land	NA,NE	161.30					161.30
B. Waste-water Handling		2.23	6.61				8.84
C. Waste Incineration	6.75	3.27	0.88				10.89
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	3,376.20
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,472.72

[(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.

1997

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2013 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)]	**3,495.43**	**437.78**	**567.87**	**23.72**	**82.36**	**1.30**	**4,608.46**
1. Energy	**1,992.27**	**5.16**	**48.99**				**2,046.42**
A. Fuel Combustion (Sectoral Approach)	1,928.42	4.27	48.99				1,981.67
1. Energy Industries	8.17	0.03	0.12				8.33
2. Manufacturing Industries and Construction	467.37	0.35	22.64				490.36
3. Transport	615.75	2.26	19.35				637.36
4. Other Sectors	837.12	1.62	6.88				845.62
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	63.85	0.89	NA,NO				64.74
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	63.85	0.89	NA,NO				64.74
2. Industrial Processes	**493.42**	**0.60**	**41.11**	**23.72**	**82.36**	**1.30**	**642.52**
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	446.44	0.60	NA	NA,NE,NO	82.36	NA,NO	529.40
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)]				23.72	NA,NO	1.30	25.03
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.55**		**4.71**				**8.26**
4. Agriculture		**254.07**	**394.76**				**648.83**
A. Enteric Fermentation		225.83					225.83
B. Manure Management		28.23	42.64				70.88
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	352.12				352.12
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)]	**999.68**	**7.70**	**70.62**				**1,078.00**
A. Forest Land	-81.51	NE,NO	0.57				-80.94
B. Cropland	1,157.66	NE,NO	IE,NA,NE,NO				1,157.66
C. Grassland	-85.45	NE,NO	NE,NO				-85.45
D. Wetlands	8.98	7.70	NA,NO				16.67
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	70.05				70.05
6. Waste	**6.50**	**170.25**	**7.69**				**184.44**
A. Solid Waste Disposal on Land	NA,NE	164.70					164.70
B. Waste-water Handling		2.25	6.66				8.91
C. Waste Incineration	6.50	3.13	0.84				10.47
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	3,530.46
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,608.46

(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.

1998

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2013 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)]	**3,483.15**	**447.86**	**570.22**	**35.72**	**180.13**	**1.30**	**4,718.40**
1. Energy	**1,974.38**	**5.34**	**49.50**				**2,029.21**
A. Fuel Combustion (Sectoral Approach)	1,890.68	4.24	49.50				1,944.41
1. Energy Industries	11.11	0.03	0.13				11.27
2. Manufacturing Industries and Construction	444.57	0.33	22.88				467.79
3. Transport	619.00	2.30	19.83				641.13
4. Other Sectors	815.99	1.57	6.66				824.22
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	83.70	1.10	NA,NO				84.80
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	83.70	1.10	NA,NO				84.80
2. Industrial Processes	**521.32**	**0.44**	**35.84**	**35.72**	**180.13**	**1.30**	**774.75**
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	466.53	0.44	NA	NA,NE,NO	180.13	NA,NO	647.11
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)]				35.72	NA,NO	1.30	37.03
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.80**		**4.84**				**8.63**
4. Agriculture		**259.53**	**401.25**				**660.79**
A. Enteric Fermentation		230.38					230.38
B. Manure Management		29.16	43.63				72.78
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	357.63				357.63
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)]	**978.15**	**7.80**	**71.16**				**1,057.11**
A. Forest Land	-89.67	NE,NO	0.64				-89.03
B. Cropland	1,151.70	NE,NO	IE,NA,NE,NO				1,151.70
C. Grassland	-92.98	NE,NO	NE,NO				-92.98
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	70.51				70.51
6. Waste	**5.51**	**174.74**	**7.65**				**187.90**
A. Solid Waste Disposal on Land	NA,NE	169.61					169.61
B. Waste-water Handling		2.28	6.74				9.02
C. Waste Incineration	5.51	2.69	0.72				8.93
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	3,661.29
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,718.40

(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.

1999

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2013 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)	**3,668.11**	**452.90**	**592.42**	**40.45**	**173.21**	**1.30**	**4,928.40**
1. Energy	**2,031.73**	**5.18**	**61.20**				**2,098.11**
A. Fuel Combustion (Sectoral Approach)	1,920.46	3.60	61.20				1,985.26
1. Energy Industries	8.24	0.03	0.12				8.40
2. Manufacturing Industries and Construction	470.11	0.36	25.04				495.50
3. Transport	640.69	1.67	29.49				671.84
4. Other Sectors	801.42	1.54	6.55				809.51
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	111.27	1.58	NA,NO				112.86
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	111.27	1.58	NA,NO				112.86
2. Industrial Processes	**670.41**	**0.68**	**36.18**	**40.45**	**173.21**	**1.30**	**922.23**
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	608.52	0.68	NA	NA,NE,NO	173.21	NA,NO	782.41
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)				40.45	NA,NO	1.30	41.75
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.47**		**4.82**				**8.29**
4. Agriculture		**259.52**	**410.92**				**670.44**
A. Enteric Fermentation		230.26					230.26
B. Manure Management		29.26	43.74				73.00
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	367.18				367.18
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)	**957.99**	**7.80**	**71.68**				**1,037.48**
A. Forest Land	-95.55	NE,NO	0.67				-94.88
B. Cropland	1,145.63	NE,NO	IE,NA,NE,NO				1,145.63
C. Grassland	-101.19	NE,NO	NE,NO				-101.19
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	71.01				71.01
6. Waste	**4.51**	**179.72**	**7.62**				**191.85**
A. Solid Waste Disposal on Land	NA,NE	174.99					174.99
B. Waste-water Handling		2.31	6.83				9.14
C. Waste Incineration	4.51	2.25	0.61				7.36
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	3,890.92
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,928.40

(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.

2000

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2013 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)]	**3,710.62**	**448.07**	**567.59**	**35.78**	**127.16**	**1.37**	**4,890.60**
1. Energy	**1,975.42**	**5.24**	**61.05**				**2,041.71**
A. Fuel Combustion (Sectoral Approach)	1,822.28	3.47	61.05				1,886.79
1. Energy Industries	7.24	0.03	0.12				7.40
2. Manufacturing Industries and Construction	423.71	0.33	25.49				449.53
3. Transport	642.83	1.65	29.29				673.77
4. Other Sectors	748.50	1.45	6.14				756.09
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	153.15	1.77	NA,NO				154.92
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	153.15	1.77	NA,NO				154.92
2. Industrial Processes	**792.55**	**0.94**	**18.63**	**35.78**	**127.16**	**1.37**	**976.45**
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	726.46	0.94	NA	NA,NE,NO	127.16	NA,NO	854.57
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)]				35.78	NA,NO	1.37	37.16
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.71**		**4.60**				**8.31**
4. Agriculture		**249.78**	**403.09**				**652.88**
A. Enteric Fermentation		221.33					221.33
B. Manure Management		28.45	43.13				71.58
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	359.96				359.96
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)]	**934.70**	**7.80**	**72.52**				**1,015.02**
A. Forest Land	-107.07	NE,NO	0.86				-106.21
B. Cropland	1,139.59	NE,NO	IE,NA,NE,NO				1,139.59
C. Grassland	-106.93	NE,NO	NE,NO				-106.93
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	71.65				71.65
6. Waste	**4.24**	**184.30**	**7.70**				**196.23**
A. Solid Waste Disposal on Land	NA,NE	179.59					179.59
B. Waste-water Handling		2.34	6.92				9.26
C. Waste Incineration	4.24	2.20	0.59				7.03
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	3,875.58
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,890.60

(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.

2001

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Inventory 2001
Submission 2013 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)]	**3,693.34**	**456.48**	**560.22**	**40.27**	**91.66**	**1.37**	**4,843.34**
1. Energy	**1,939.14**	**5.19**	**60.23**				**2,004.55**
A. Fuel Combustion (Sectoral Approach)	1,795.37	3.35	60.23				1,858.95
1. Energy Industries	6.55	0.03	0.12				6.71
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	664.36	1.28	5.45				671.09
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	143.77	1.84	NA,NO				145.61
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	143.77	1.84	NA,NO				145.61
2. Industrial Processes	**826.74**	**0.91**	**16.15**	**40.27**	**91.66**	**1.37**	**977.11**
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	767.26	0.91	NA	NA,NE,NO	91.66	NA,NO	859.82
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)]				40.27	0.01	1.37	41.66
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.37**		**4.28**				**7.65**
4. Agriculture		**252.03**	**398.82**				**650.84**
A. Enteric Fermentation		223.06					223.06
B. Manure Management		28.96	41.67				70.63
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	357.14				357.14
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)]	**920.06**	**7.80**	**73.01**				**1,000.87**
A. Forest Land	-112.80	NE,NO	0.89				-111.91
B. Cropland	1,133.44	NE,NO	IE,NA,NE,NO				1,133.44
C. Grassland	-109.69	NE,NO	NE,NO				-109.69
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	72.12				72.12
6. Waste	**4.03**	**190.55**	**7.73**				**202.32**
A. Solid Waste Disposal on Land	NA,NE	186.02					186.02
B. Waste-water Handling		2.37	7.01				9.38
C. Waste Incineration	4.03	1.99	0.54				6.57
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	3,842.47
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,843.34

(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.

2002

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2013 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)	**3,765.44**	**454.40**	**528.05**	**38.10**	**72.54**	**1.37**	**4,859.90**
1. Energy	**2,014.81**	**5.34**	**59.54**				**2,079.69**
A. Fuel Combustion (Sectoral Approach)	1,867.25	3.50	59.54				1,930.29
1. Energy Industries	8.52	0.04	0.12				8.68
2. Manufacturing Industries and Construction	473.73	0.35	23.52				497.60
3. Transport	657.22	1.69	29.89				688.80
4. Other Sectors	727.78	1.42	6.01				735.20
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	147.57	1.84	NA,NO				149.41
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	147.57	1.84	NA,NO				149.41
2. Industrial Processes	**840.90**	**0.97**	**NA,NE,NO**	**38.10**	**72.54**	**1.37**	**953.89**
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	800.68	0.97	NA	NA,NE,NO	72.54	NA,NO	874.19
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)				38.10	0.01	1.37	39.48
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.39**		**4.03**				**7.42**
4. Agriculture		**246.26**	**383.02**				**629.28**
A. Enteric Fermentation		218.32					218.32
B. Manure Management		27.93	41.75				69.68
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	341.27				341.27
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)	**902.58**	**7.80**	**73.71**				**984.09**
A. Forest Land	-120.89	NE,NO	0.96				-119.94
B. Cropland	1,127.26	NE,NO	IE,NA,NE,NO				1,127.26
C. Grassland	-112.90	NE,NO	NE,NO				-112.90
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	72.75				72.75
6. Waste	**3.75**	**194.03**	**7.75**				**205.53**
A. Solid Waste Disposal on Land	NA,NE	187.62					187.62
B. Waste-water Handling		4.37	7.06				11.43
C. Waste Incineration	3.75	1.86	0.50				6.12
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	3,875.81
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,859.90

(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.

2003

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2013 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)]	**3,734.68**	**453.09**	**518.17**	**47.19**	**59.79**	**1.37**	**4,814.29**
1. Energy	**2,007.69**	**5.31**	**58.78**				**2,071.78**
A. Fuel Combustion (Sectoral Approach)	1,871.18	3.52	58.78				1,933.48
1. Energy Industries	7.79	0.03	0.12				7.95
2. Manufacturing Industries and Construction	425.39	0.33	21.51				447.23
3. Transport	751.18	1.81	31.44				784.43
4. Other Sectors	686.82	1.35	5.70				693.88
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	136.51	1.79	NA,NO				138.30
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	136.51	1.79	NA,NO				138.30
2. Industrial Processes	**840.36**	**0.94**	**NA,NE,NO**	**47.19**	**59.79**	**1.37**	**949.65**
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	806.41	0.94	NA	NA,NE,NO	59.78	NA,NO	867.13
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)]				47.19	0.00	1.37	48.57
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.33**		**3.88**				**7.21**
4. Agriculture		**243.63**	**373.54**				**617.17**
A. Enteric Fermentation		216.13					216.13
B. Manure Management		27.50	41.42				68.92
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	332.12				332.12
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)]	**880.07**	**7.80**	**74.15**				**962.02**
A. Forest Land	-131.98	NE,NO	0.98				-131.00
B. Cropland	1,123.44	NE,NO	IE,NA,NE,NO				1,123.44
C. Grassland	-120.49	NE,NO	NE,NO				-120.49
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	NE,NO	NE	NE				NE,NO
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	73.17				73.17
6. Waste	**3.22**	**195.41**	**7.83**				**206.46**
A. Solid Waste Disposal on Land	NA,NE	189.13					189.13
B. Waste-water Handling		4.41	7.11				11.52
C. Waste Incineration	3.22	1.62	0.44				5.28
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	3,852.26
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,814.29

(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.

2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2013 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)	**3,781.85**	**454.88**	**515.89**	**50.19**	**38.58**	**1.38**	**4,842.77**
1. Energy	**2,052.17**	**5.52**	**64.13**				**2,121.82**
A. Fuel Combustion (Sectoral Approach)	1,929.27	3.59	64.13				1,996.99
1. Energy Industries	7.43	0.04	0.12				7.59
2. Manufacturing Industries and Construction	458.70	0.36	25.78				484.84
3. Transport	803.26	1.91	32.77				837.93
4. Other Sectors	659.88	1.29	5.46				666.62
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	122.90	1.93	NA,NO				124.83
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	122.90	1.93	NA,NO				124.83
2. Industrial Processes	**863.60**	**0.96**	**NA,NE,NO**	**50.19**	**38.58**	**1.38**	**954.71**
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	811.76	0.96	NA	NA,NE,NO	38.58	NA,NO	851.30
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)				50.19	0.00	1.38	51.57
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.60**		**3.57**				**7.16**
4. Agriculture		**239.85**	**365.68**				**605.53**
A. Enteric Fermentation		212.78					212.78
B. Manure Management		27.07	41.27				68.34
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE,NO	324.41				324.41
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)	**855.41**	**7.80**	**74.62**				**937.83**
A. Forest Land	-138.95	NE,NO	1.03				-137.92
B. Cropland	1,117.47	NE,NO	IE,NA,NE,NO				1,117.47
C. Grassland	-132.38	NE,NO	NE,NO				-132.38
D. Wetlands	9.11	7.80	NA,NO				16.91
E. Settlements	0.16	NE	NE				0.16
F. Other Land	NE	NE	NE				NE
G. Other	NA,NE,NO	NA,NE,NO	73.59				73.59
6. Waste	**7.09**	**200.74**	**7.90**				**215.72**
A. Solid Waste Disposal on Land	NA,NE	195.06					195.06
B. Waste-water Handling		4.45	7.18				11.63
C. Waste Incineration	7.09	0.98	0.44				8.50
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	3,904.94
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,842.77

(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.

2005

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2013 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)	**3,674.82**	**450.57**	**524.90**	**58.42**	**26.10**	**2.64**	**4,737.45**
1. Energy	**1,998.59**	**5.30**	**71.70**				**2,075.58**
A. Fuel Combustion (Sectoral Approach)	1,882.24	3.21	71.70				1,957.14
1. Energy Industries	9.22	0.03	0.12				9.37
2. Manufacturing Industries and Construction	419.21	0.35	27.84				447.40
3. Transport	808.94	1.57	38.43				848.93
4. Other Sectors	644.87	1.26	5.31				651.44
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	116.36	2.09	NA,NO				118.45
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	116.36	2.09	NA,NO				118.45
2. Industrial Processes	**846.48**	**0.97**	**NA,NE,NO**	**58.42**	**26.10**	**2.64**	**934.60**
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	790.76	0.97	NA	NA,NE,NO	26.09	NA,NO	817.82
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)				58.42	0.00	2.64	61.06
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.53**		**3.35**				**6.88**
4. Agriculture		**241.79**	**366.51**				**608.30**
A. Enteric Fermentation		214.19					214.19
B. Manure Management		27.60	41.74				69.34
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE,NO	324.77				324.77
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)	**821.88**	**7.80**	**75.22**				**904.91**
A. Forest Land	-158.87	NE,NO	1.05				-157.82
B. Cropland	1,112.15	NE,NO	IE,NA,NE,NO				1,112.15
C. Grassland	-140.68	NE,NO	NE,NO				-140.68
D. Wetlands	9.11	7.80	NA,NE,NO				16.91
E. Settlements	0.18	NE	NE				0.18
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	74.17				74.17
6. Waste	**4.33**	**194.71**	**8.13**				**207.17**
A. Solid Waste Disposal on Land	NA,NE	189.38					189.38
B. Waste-water Handling		4.54	7.39				11.94
C. Waste Incineration	4.33	0.37	0.27				4.97
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	3,832.54
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	4,737.45

(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.

2006

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2013 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)	**3,832.12**	**473.55**	**551.76**	**58.76**	**333.22**	**2.64**	**5,252.05**
1. Energy	**2,066.21**	**6.31**	**70.45**				**2,142.97**
A. Fuel Combustion (Sectoral Approach)	1,929.57	3.28	70.45				2,003.30
1. Energy Industries	8.49	0.06	0.21				8.75
2. Manufacturing Industries and Construction	406.89	0.32	25.31				432.52
3. Transport	951.27	1.80	40.30				993.37
4. Other Sectors	562.92	1.10	4.64				568.66
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	136.65	3.03	NA,NO				139.67
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	136.65	3.03	NA,NO				139.67
2. Industrial Processes	**954.33**	**0.99**	**NA,NE,NO**	**58.76**	**333.22**	**2.64**	**1,349.95**
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	891.62	0.99	NA	NA,NE,NO	333.22	NA,NO	1,225.83
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)				58.76	0.00	2.64	61.40
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.89**		**3.36**				**7.25**
4. Agriculture		**245.95**	**392.70**				**638.65**
A. Enteric Fermentation		217.24					217.24
B. Manure Management		28.72	41.70				70.42
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils (3)		NA,NE,NO	351.00				351.00
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)	**802.80**	**9.10**	**76.61**				**888.51**
A. Forest Land	-165.34	NE,NO	1.11				-164.23
B. Cropland	1,105.92	NE,NO	IE,NA,NE,NO				1,105.92
C. Grassland	-147.99	0.07	0.03				-147.89
D. Wetlands	9.11	9.03	0.45				18.60
E. Settlements	1.09	NE	NE				1.09
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	75.02				75.02
6. Waste	**4.88**	**211.19**	**8.64**				**224.71**
A. Solid Waste Disposal on Land	NA,NE	205.50					205.50
B. Waste-water Handling		4.66	7.60				12.26
C. Waste Incineration	4.88	0.36	0.30				5.53
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	4,363.54
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,252.05

(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.

2007

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2013 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)]	**4,072.59**	**474.05**	**570.44**	**61.98**	**281.13**	**3.00**	**5,463.19**
1. Energy	**2,121.33**	**7.30**	**70.84**				**2,199.46**
A. Fuel Combustion (Sectoral Approach)	1,975.57	3.34	70.84				2,049.75
1. Energy Industries	23.81	0.07	0.25				24.12
2. Manufacturing Industries and Construction	386.54	0.31	25.38				412.24
3. Transport	986.01	1.84	40.45				1,028.30
4. Other Sectors	579.20	1.13	4.76				585.09
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	145.76	3.96	NA,NO				149.71
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	145.76	3.96	NA,NO				149.71
2. Industrial Processes	**1,153.08**	**1.04**	**NA,NE,NO**	**61.98**	**281.13**	**3.00**	**1,500.22**
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	1,088.56	1.04	NA	NA,NE,NO	281.13	NA,NO	1,370.72
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)]				61.98	0.00	3.00	64.98
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**4.03**		**3.80**				**7.83**
4. Agriculture		**250.09**	**409.65**				**659.74**
A. Enteric Fermentation		220.42					220.42
B. Manure Management		29.67	42.46				72.13
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	367.19				367.19
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)]	**786.19**	**8.22**	**77.09**				**871.50**
A. Forest Land	-172.98	NE,NO	1.14				-171.84
B. Cropland	1,100.83	NE,NO	IE,NA,NE,NO				1,100.83
C. Grassland	-151.48	NE,NO	NE,NO				-151.48
D. Wetlands	9.60	8.22	NA,NE,NO				17.82
E. Settlements	0.22	NE	NE				0.22
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	75.95				75.95
6. Waste	**7.98**	**207.40**	**9.06**				**224.44**
A. Solid Waste Disposal on Land	NA,NE	202.42					202.42
B. Waste-water Handling		3.79	7.80				11.59
C. Waste Incineration	7.98	0.35	0.33				8.66
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	4,591.69
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,463.19

[(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.

2008

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2013 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)]	**4,377.83**	**469.70**	**582.13**	**70.64**	**349.00**	**3.15**	**5,852.45**
1. Energy	**1,999.42**	**7.47**	**67.78**				**2,074.66**
A. Fuel Combustion (Sectoral Approach)	1,815.15	3.11	67.78				1,886.04
1. Energy Industries	7.92	0.05	0.20				8.17
2. Manufacturing Industries and Construction	344.25	0.28	24.23				368.76
3. Transport	932.13	1.74	38.99				972.86
4. Other Sectors	530.86	1.03	4.37				536.25
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	184.27	4.35	NA,NO				188.62
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	184.27	4.35	NA,NO				188.62
2. Industrial Processes	**1,595.86**	**0.88**	**NA,NE,NO**	**70.64**	**349.00**	**3.15**	**2,019.53**
A. Mineral Products	62.86	NE,NO	NE,NO				62.86
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,533.00	0.88	NA	NA,NE,NO	349.00	NA,NO	1,882.88
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)]				70.64	0.00	3.15	73.79
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.55**		**3.63**				**7.18**
4. Agriculture		**252.64**	**423.65**				**676.29**
A. Enteric Fermentation		223.04					223.04
B. Manure Management		29.60	41.44				71.04
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	382.21				382.21
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)]	**772.70**	**8.22**	**77.93**				**858.86**
A. Forest Land	-177.07	NE,NO	1.13				-175.93
B. Cropland	1,095.15	NE,NO	IE,NA,NE,NO				1,095.15
C. Grassland	-155.06	NE,NO	NE,NO				-155.06
D. Wetlands	9.60	8.22	NA,NE,NO				17.82
E. Settlements	0.08	NE	NE				0.08
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	76.80				76.80
6. Waste	**6.31**	**200.49**	**9.13**				**215.93**
A. Solid Waste Disposal on Land	NA,NE	195.74					195.74
B. Waste-water Handling		3.53	7.85				11.38
C. Waste Incineration	6.31	0.33	0.30				6.93
D. Other	NA	0.89	0.99				1.88
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	4,993.59
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,852.45

(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.

2009

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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)]	**4,319.39**	**467.18**	**547.96**	**95.01**	**152.75**	**3.17**	**5,585.47**
1. Energy	**1,952.48**	**7.97**	**60.77**				**2,021.22**
A. Fuel Combustion (Sectoral Approach)	1,784.02	3.14	60.77				1,847.93
1. Energy Industries	8.81	0.05	0.18				9.04
2. Manufacturing Industries and Construction	247.27	0.20	16.69				264.17
3. Transport	905.31	1.69	38.83				945.84
4. Other Sectors	622.64	1.19	5.06				628.89
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	168.45	4.83	NA,NO				173.29
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	168.45	4.83	NA,NO				173.29
2. Industrial Processes	**1,608.77**	**0.91**	**NA,NE,NO**	**95.01**	**152.75**	**3.17**	**1,860.61**
A. Mineral Products	30.05	NE,NO	NE,NO				30.05
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,578.72	0.91	NA	NA,NE,NO	152.75	NA,NO	1,732.38
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)]				95.01	0.00	3.17	98.19
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**3.16**		**3.15**				**6.31**
4. Agriculture		**255.43**	**396.00**				**651.43**
A. Enteric Fermentation		225.68					225.68
B. Manure Management		29.75	42.92				72.68
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils[(3)]		NA,NE,NO	353.08				353.08
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)]	**747.56**	**8.33**	**78.69**				**834.57**
A. Forest Land	-191.03	NE,NO	1.17				-189.85
B. Cropland	1,087.18	NE,NO	IE,NA,NE,NO				1,087.18
C. Grassland	-158.40	NE,NO	NE,NO				-158.40
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.08	NE	NE				0.08
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	77.52				77.52
6. Waste	**7.43**	**194.53**	**9.35**				**211.32**
A. Solid Waste Disposal on Land	NA,NE	189.64					189.64
B. Waste-water Handling		3.51	7.88				11.39
C. Waste Incineration	7.43	0.32	0.29				8.03
D. Other	NA	1.07	1.18				2.25
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	498.71	0.37	4.29				503.38
Aviation	333.88	0.05	2.92				336.85
Marine	164.84	0.32	1.37				166.53
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	4,750.90
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,585.47

(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.

2010

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

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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)]	**4,140.42**	**467.80**	**532.54**	**122.54**	**145.63**	**4.89**	**5,413.81**
1. Energy	**1,807.12**	**7.02**	**55.02**				**1,869.15**
A. Fuel Combustion (Sectoral Approach)	1,618.13	2.89	55.02				1,676.04
1. Energy Industries	6.69	0.04	0.16				6.89
2. Manufacturing Industries and Construction	199.36	0.17	13.21				212.74
3. Transport	861.59	1.61	37.14				900.34
4. Other Sectors	550.49	1.07	4.51				556.07
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	188.99	4.13	NA,NO				193.12
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	188.99	4.13	NA,NO				193.12
2. Industrial Processes	**1,615.82**	**0.90**	**NA,NE,NO**	**122.54**	**145.63**	**4.89**	**1,889.78**
A. Mineral Products	10.64	NE,NO	NE,NO				10.64
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,605.18	0.90	NA	NA,NE,NO	145.63	NA,NO	1,751.71
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)]				122.54	0.01	4.89	127.43
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**2.74**		**3.41**				**6.15**
4. Agriculture		**257.19**	**385.66**				**642.84**
A. Enteric Fermentation		227.60					227.60
B. Manure Management		29.59	42.94				72.53
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils [(3)]		NA,NE,NO	342.72				342.72
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)]	**708.61**	**8.33**	**78.86**				**795.80**
A. Forest Land	-215.22	NE,NO	1.21				-214.02
B. Cropland	1,078.95	NE,NO	IE,NA,NE,NO				1,078.95
C. Grassland	-164.92	NE,NO	NE,NO				-164.92
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.08	NE	NE				0.08
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	77.65				77.65
6. Waste	**6.13**	**194.36**	**9.59**				**210.08**
A. Solid Waste Disposal on Land	NA,NE	189.27					189.27
B. Waste-water Handling		3.51	7.93				11.44
C. Waste Incineration	6.13	0.29	0.25				6.67
D. Other	NA	1.28	1.42				2.70
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: [(4)]							
International Bunkers	559.61	0.41	4.81				564.84
Aviation	377.26	0.06	3.30				380.62
Marine	182.35	0.36	1.51				184.21
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	4,618.01
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,413.81

(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.

2011

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

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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)	**3,991.45**	**452.67**	**527.70**	**121.35**	**63.22**	**3.13**	**5,159.53**
1. Energy	**1,712.12**	**6.08**	**51.56**				**1,769.76**
A. Fuel Combustion (Sectoral Approach)	1,533.43	2.71	51.56				1,587.70
1. Energy Industries	6.85	0.04	0.14				7.03
2. Manufacturing Industries and Construction	181.94	0.14	11.38				193.47
3. Transport	826.36	1.53	35.80				863.69
4. Other Sectors	518.29	1.00	4.23				523.52
5. Other	NA,NO	NA,NO	NA,NO				NA,NO
B. Fugitive Emissions from Fuels	178.68	3.37	NA,NO				182.05
1. Solid Fuels	NA,NO	NA,NO	NA,NO				NA,NO
2. Oil and Natural Gas	178.68	3.37	NA,NO				182.05
2. Industrial Processes	**1,609.87**	**0.87**	**NA,NE,NO**	**121.35**	**63.22**	**3.13**	**1,798.44**
A. Mineral Products	21.15	NE,NO	NE,NO				21.15
B. Chemical Industry	NA,NO	NO	NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	1,588.72	0.87	NA	NA,NE,NO	63.22	NA,NO	1,652.81
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)				121.35	0.00	3.13	124.49
G. Other	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	**2.81**		**3.49**				**6.30**
4. Agriculture		**256.86**	**383.82**				**640.68**
A. Enteric Fermentation		226.97					226.97
B. Manure Management		29.89	43.86				73.75
C. Rice Cultivation		NA,NO					NA,NO
D. Agricultural Soils(3)		NA,NE,NO	339.96				339.96
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)	**658.70**	**8.33**	**79.25**				**746.28**
A. Forest Land	-250.67	NE,NO	1.22				-249.45
B. Cropland	1,072.41	NE,NO	IE,NA,NE,NO				1,072.41
C. Grassland	-173.21	NE,NO	NE,NO				-173.21
D. Wetlands	9.72	8.33	NA,NE,NO				18.05
E. Settlements	0.46	NE	NE				0.46
F. Other Land	NE	NE	NE				NE
G. Other	NE,NO	NA,NE,NO	78.03				78.03
6. Waste	**7.96**	**180.53**	**9.59**				**198.07**
A. Solid Waste Disposal on Land	NA,NE	175.51					175.51
B. Waste-water Handling		3.53	7.98				11.51
C. Waste Incineration	7.96	0.29	0.28				8.53
D. Other	NA	1.20	1.33				2.53
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Memo Items: (4)							
International Bunkers	620.60	0.45	5.34				626.39
Aviation	421.93	0.06	3.70				425.69
Marine	198.66	0.39	1.64				200.70
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	4,413.25
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	5,159.53

(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 V. 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 Hafnarfjörður, 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 Straumsvík 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 2,158.6 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 2,158.6 Gg Total industrial CO_2 emissions from the project in 2011 were 128.8 Gg or 6.0% of the 1990 CO_2 emissions. This is higher than the 5% threshold in paragraph 2.
Reporting of CO_2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2011 to 85,069 tonnes of aluminium (185,267 tonnes in 2011 compared to 100,198 tonnes in 1995). The resulting CO_2 emissions are 129 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the plant and year specific C-content of the electrodes. The implied emission factor in for the expanded part in 2011 is 1.514 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 2011 the total energy consumption was 2,907 tonnes of residual fuel oil and 165 tonnes of LPG leading to emissions of 9.5 Gg of GHG. The EF for residual fuel oil is 3.08 t CO_2-equivalents per tonne of fuel. The EF for LPG is 2.95 t CO_2-equivalents per tonne of fuel. The IEF for energy use is 0.05 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2011 the total use of electricity was 2,864 GWh, thereof 1,315 GWh were used for the expansion project. As stated in chapter 3.2., almost all energy in Iceland is produced from renewable energy sources (99.99%). Electricity for all heavy industry in Iceland is produced from renewable energy sources. The average emission per kWh from electricity production in Iceland is 11.7 CO_2/kWh. The total CO_2 emissions from the electricity use for the project amounts to 15.4 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to 600 Gg. The resulting emissions from electricity use in the project would thus have amounted to 788.6 Gg. The resulting emissions savings are 773.2 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

[#] 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	**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 cannot 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 2,158.6 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 2,158.6 Gg. Total industrial CO_2 emissions from the project in 2011 were 144 Gg or 6.7% of the 1990 CO_2 emissions. This is higher than the 5% threshold in paragraph 2.
Reporting of CO_2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2011 to 42,401 tonnes of ferrosilicon (all production in furnace 3). The resulting CO_2 emissions are 144 Gg. CO_2 emissions are calculated based on mass balance, using plant and year specific C-content of input (coal and coke as reducing agents) and output (FeSi, microsilica). The implied emission factor for the expanded part in 2011 was 3.394 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 2011 the total energy consumption was 367 tonnes of gasoil leading to emissions of 1.2 Gg of GHG. The EF for gasoil is 3.18 t CO_2-equivalents per tonne of fuel. These emissions are reported in the Energy sector. In 2011 the total use of electricity was 944 GWh, thereof 395 GWh were used for the expansion project. As stated in chapter 3.2., almost all energy in Iceland is produced from renewable energy sources (99.99%). Electricity for all heavy industry in Iceland is produced from renewable energy sources. The average emissions per kWh from electricity production in Iceland are 11.7 g. The total CO_2 emissions from the electricity use for the project amounts to 4.9 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to 600 g. The resulting emissions from the project would thus have amounted to 237 Gg. The resulting emissions savings are 232 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.

[#] 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	**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 2,158.6 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 2,158.6 Gg (according to Iceland's Initial Report under the Kyoto Protocol). Total industrial CO_2 emissions from the project in 2011 were 421.9 Gg or 19.5% of the 1990 CO_2 emissions. This is higher than the 5% threshold in paragraph 2.
Reporting of CO_2 emissions from the project, according to paragraph 5	The production increase resulting from this project amounted in 2011 to 280,300 tonnes of aluminium. The resulting CO_2 emissions are 422 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the plant and year specific C-content of the electrodes. The implied emission factor in 2011 is thus 1.505 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	Century Aluminium uses LPG and gasoil for heating of melting pots. In 2011 the total fuel consumption was 447 tonnes of gasoil and 265 tonnes of LPG leading to emissions of 2.2 Gg of GHG. The EF for gasoil is

paragraph 5	3.18 t CO_2-equivalents per tonne of fuel. The EF for LPG is 2.95 t CO_2-equivalents per tonne of fuel. The IEF for energy use is 0.008 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2011 the total use of electricity was 4,164 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 11.7 g/kWh. The total CO_2 emissions from the electricity used for the project amounts to 49 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to approximately 600 g. The resulting emissions from the project would thus have amounted to 2,497 Gg. The resulting emissions savings are 2,448 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: o All pots are closed and the pot gases are collected and cleaned via a dry absorption unit; the technique is defined as BAT. o Prebake anodes are used and automatic multiple point feed. o Besides that computer control is used in the potlines to minimize energy use and formation of PFC. Century Aluminium is implementing an environmental management system according to ISO 14001. The system will be certified in autumn 2013.

[#] 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.
Evidence that the Party fulfils paragraph 2.(a)	Iceland's total 1990 CO_2 emissions amounted to 2,158.6 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 2,158.6 Gg (according to Iceland's Initial Report under the Kyoto Protocol). Total industrial CO_2 emissions from the project in 2011 were 514 Gg or 23.8% 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 2011 to 340,752 tonnes of aluminium. The resulting CO_2 emissions are 514 Gg of CO_2. CO_2 emissions are calculated based on the quantity of electrodes used in the process and the plant and year specific C-content of the electrodes. The implied emission factor in 2011 is 1.509 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	Alcoa Fjarðaál uses LPG and gasoil for heating of melting pots. In 2011 the total fuel consumption was 415 tonnes of gasoil and 273 tonnes of LPG leading to emissions of 2.1 Gg of GHG. The EF for gasoil is 3.18 t CO_2-equivalents per tonne of fuel. The EF for LPG is 2.95 t CO_2-

paragraph 5	equivalents per tonne of fuel. The IEF for energy use is 0.006 t CO_2-equivalents per tonne of aluminium. These emissions are reported in the Energy sector. In 2011 the total use of electricity was 4,797 GWh. As stated before all the electricity used is produced from renewable sources. The average emission from this electricity is 11.7 g/kWh. The total CO_2 emissions from the electricity use for the project amounts to 56 Gg. Had the energy been from gas fired power plant the per kWh emissions would amount to approximately 600 g. The resulting emissions from the project would thus have amounted to 2,876 Gg. The resulting emissions savings are 2820 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. Alcoa Fjarðaál has implemented an ISO 14001 environmental management system. The environmental management system was certified in 2012.

[#] All references to paragraphs are relating to the paragraphs of decision 14/CP.7